

# METHODS OF TREATING DISEASES RESPONSIVE TO INDUCTION OF APOPTOSIS AND SCREENING ASSAYS

## RELATED APPLICATIONS

[0001] The present application claims the benefit under 35 U.S.C. §119(e) of the following United States provisional applications which are wholly incorporated by reference: US 60/463,649, filed April 18, 2003; US 60/463,662, filed April 18, 2003; US 60/484,749, filed July 7, 2003; US 60/484,750, filed July 7, 2003; and US 60/532,665, filed December 29, 2003.

## BACKGROUND OF THE INVENTION

### Field of the Invention

[0002] The present invention relates to a method of treating, preventing or ameliorating a disease responsive to induction of the caspase cascade in an animal, comprising administering to the animal a compound which binds specifically to one or more Apoptosis Inducing Proteins (AIPs). AIPs include Transferrin Receptor Related Apoptosis Inducing Proteins (TRRAIPs), Clathrin Heavy Chain Related Apoptosis Inducing Proteins (CHCRAIPs), IQ motif containing GTPase Activating Protein Related Apoptosis Inducing Proteins (IQGAPRAIPs), and Heat Shock Protein Related Apoptosis Inducing Proteins (HSPRAIPs). The present invention also relates to methods for identifying such AIP binding compounds. The invention also relates to the use of biochemical and cell based screening assays to identify AIP binding compounds that may be administered to animals for treating, preventing or ameliorating a disease responsive to induction of the caspase cascade.

### Related Art

[0003] Organisms eliminate unwanted cells by a process variously known as regulated cell death, programmed cell death or apoptosis. Such cell death occurs as a normal aspect of animal development, as well as in tissue

homeostasis and aging (Glucksmann, A., *Biol. Rev. Cambridge Philos. Soc.* 26:59-86 (1951); Glucksmann, A., *Archives de Biologie* 76:419-437 (1965); Ellis, *et al.*, *Dev.* 112:591-603 (1991); Vaux, *et al.*, *Cell* 76:777-779 (1994)). Apoptosis regulates cell number, facilitates morphogenesis, removes harmful or otherwise abnormal cells and eliminates cells that have already performed their function. Additionally, apoptosis occurs in response to various physiological stresses, such as hypoxia or ischemia (PCT published application WO96/20721).

[0004] There are a number of morphological changes shared by cells experiencing regulated cell death, including plasma and nuclear membrane blebbing, cell shrinkage (condensation of nucleoplasm and cytoplasm), organelle relocation and compaction, chromatin condensation and production of apoptotic bodies (membrane enclosed particles containing intracellular material) (Orrenius, S., *J. Internal Medicine* 237:529-536 (1995)).

[0005] Apoptosis is achieved through an endogenous mechanism of cellular suicide (Wyllie, A.H., in *Cell Death in Biology and Pathology*, Bowen and Lockshin, eds., Chapman and Hall (1981), pp. 9-34). A cell activates its internally encoded suicide program as a result of either internal or external signals. The suicide program is executed through the activation of a carefully regulated genetic program (Wyllie, *et al.*, *Int. Rev. Cyt.* 68:251 (1980); Ellis, *et al.*, *Ann. Rev. Cell Bio.* 7:663 (1991)). Apoptotic cells and bodies are usually recognized and cleared by neighboring cells or macrophages before lysis. Because of this clearance mechanism, inflammation is not induced despite the clearance of great numbers of cells (Orrenius, S., *J. Internal Medicine* 237:529-536 (1995)).

[0006] It has been found that a group of proteases are a key element in apoptosis (see, e.g., Thornberry, *Chemistry and Biology* 5:R97-R103 (1998); Thornberry, *British Med. Bull.* 53:478-490 (1996)). Genetic studies in the nematode *Caenorhabditis elegans* revealed that apoptotic cell death involves at least 14 genes, 2 of which are the pro-apoptotic (death-promoting) *ced* (for *cell death abnormal*) genes, *ced-3* and *ced-4*. CED-3 is homologous to

interleukin 1 beta-converting enzyme, a cysteine protease, which is now called caspase-1. When these data were ultimately applied to mammals, and upon further extensive investigation, it was found that the mammalian apoptosis system appears to involve a cascade of caspases, or a system that behaves like a cascade of caspases. At present, the caspase family of cysteine proteases comprises 14 different members, and more may be discovered in the future. All known caspases are synthesized as zymogens that require cleavage at an aspartyl residue prior to forming the active enzyme. Thus, caspases are capable of activating other caspases, in the manner of an amplifying cascade.

[0007] Apoptosis and caspases are thought to be crucial in the development of cancer (*Apoptosis and Cancer Chemotherapy*, Hickman and Dive, eds., Humana Press (1999)). There is mounting evidence that cancer cells, while containing caspases, lack parts of the molecular machinery that activates the caspase cascade. This makes the cancer cells lose their capacity to undergo cellular suicide and the cells become cancerous. In the case of the apoptosis process, control points are known to exist that represent points for intervention leading to activation. These control points include the CED-9-BCL-like and CED-3-ICE-like gene family products, which are intrinsic proteins regulating the decision of a cell to survive or die and executing part of the cell death process itself, respectively (see, Schmitt, *et al.*, *Biochem. Cell. Biol.* 75:301-314 (1997)). BCL-like proteins include BCL-xL and BAX-alpha, which appear to function upstream of caspase activation. BCL-xL appears to prevent activation of the apoptotic protease cascade, whereas BAX-alpha accelerates activation of the apoptotic protease cascade.

[0008] It has been shown that chemotherapeutic (anti-cancer) drugs can trigger cancer cells to undergo suicide by activating the dormant caspase cascade. This may be a crucial aspect of the mode of action of most, if not all, known anticancer drugs (Los, *et al.*, *Blood* 90:3118-3129 (1997); Friesen, *et al.*, *Nat. Med.* 2:574 (1996)). The mechanism of action of current antineoplastic drugs frequently involves an attack at specific phases of the cell cycle. In brief, the cell cycle refers to the stages through which cells normally

progress during their lifetime. Normally, cells exist in a resting phase termed G<sub>0</sub>. During multiplication, cells progress to a stage in which DNA synthesis occurs, termed S. Later, cell division, or mitosis occurs, in a phase called M. Antineoplastic drugs, such as cytosine arabinoside, hydroxyurea, 6-mercaptopurine, and methotrexate are S phase specific, whereas antineoplastic drugs, such as vincristine, vinblastine, and paclitaxel are M phase specific. Many slow growing tumors, e.g. colon cancers, exist primarily in the G<sub>0</sub> phase, whereas rapidly proliferating normal tissues, for example bone marrow, exist primarily in the S or M phase. Thus, a drug like 6-mercaptopurine can cause bone marrow toxicity while remaining ineffective for a slow growing tumor. Further aspects of the chemotherapy of neoplastic diseases are known to those skilled in the art (*see, e.g., Hardman, et al., eds., Goodman and Gilman's The Pharmacological Basis of Therapeutics*, Ninth Edition, McGraw-Hill, New York (1996), pp. 1225-1287). Thus, it is clear that the possibility exists for the activation of the caspase cascade, although the exact mechanisms have heretofore not been clear. It is equally clear that insufficient activity of the caspase cascade and consequent apoptotic events are implicated in various types of cancer. The development of caspase cascade activators and inducers of apoptosis is a highly desirable goal in the development of therapeutically effective antineoplastic agents. Moreover, since autoimmune disease and certain degenerative diseases also involve the proliferation of abnormal cells, therapeutic treatment for these diseases could also involve the enhancement of the apoptotic process through the administration of appropriate caspase cascade activators and inducers of apoptosis.

#### SUMMARY OF THE INVENTION

[0009] As described in U.S. Patent No. 6,462,041, gambogic acid is a potent and highly efficacious activator of the caspase cascade and activator of apoptosis. The present invention relates to the discovery that apoptosis is induced upon the binding of gambogic acid to an AIP. Such binding is a

starting point for initiating the caspase cascade and apoptosis. The binding of gambogic acid to an AIP results in fast induction of apoptosis in cells, typically within 15 minutes to 10 hours.

**[0010]** Generally, the present invention relates to compounds which bind specifically to an AIP and induce fast activation of the caspase cascade and apoptosis; pharmaceutical formulations of these compounds; methods of treating, preventing or ameliorating a disease responsive to induction of the caspase cascade in an animal, comprising administering to the animal such compounds; methods for identifying such AIP binding compounds; and use of homogenous, heterogenous, protein and/or cell based screening assays to identify AIP binding compounds that may be administered to animals for treating, preventing or ameliorating a disease responsive to induction of the caspase cascade.

**[0011]** Non-limiting examples of TRRAIP binding compounds include 1-allyl-1,3,3a,4,5,12a-hexahydro-7,13-dioxo-1,5-methano-furo[3,4-d]xanthene, 1-allyl-1,3,3a,4,4a,11a-hexahydro-10,12-dioxo-1,4a-methano-furo[3,4-b]xanthene, 1-(3-methyl-2-butenyl)-3,3-dimethyl-1,3,3a,4,5,12a-hexahydro-7,13-dioxo-1,5-methano-furo[3,4-d]xanthene, 1-(3-methyl-2-butenyl)-3,3-dimethyl-1,3,3a,4,4a,11a-hexahydro-10,12-dioxo-1,4a-methano-furo[3,4-b]xanthene, 1-(3-methyl-2-butenyl)-3,3-dimethyl-1,3,3a,4,5,10a-hexahydro-7,11-dioxo-9-phenyl-1,5-methano-furo[3,4-i]chromene, and 1-(3-methyl-2-butenyl)-3,3-dimethyl-1,3,3a,4,4a,9a-hexahydro-8,10-dioxo-6-phenyl-1,4a-methano-furo[3,4-g]chromene.

**[0012]** A first embodiment of the invention relates to a method of treating, preventing or ameliorating a disease responsive to induction of the caspase cascade in an animal, comprising administering to the animal a compound which binds specifically to an AIP, wherein the compound induces activation of the caspase cascade in the animal and the disease is treated, prevented or ameliorated; with the proviso that the compound is not gambogic acid (GA) or a GA-related compound.

**[0013]** In this embodiment, the AIP may be a Transferrin Receptor Related Apoptosis Inducing Protein (TRRAIP), a Clathrin Heavy Chain Related Apoptosis Inducing Protein (CHCRAIP), an IQ motif containing GTPase Activating Protein Related Apoptosis Inducing Protein (IQGAPRAIP), or a Heat Shock Protein Related Apoptosis Inducing Protein (HSPRAIP).

**[0014]** In this embodiment, the disease may be a hyperproliferative disease. The hyperproliferative disease may be a cancer. The cancer may be Hodgkin's disease, non-Hodgkin's lymphomas, acute and chronic lymphocytic leukemias, multiple myeloma, neuroblastoma, breast carcinomas, ovarian carcinomas, lung carcinomas, Wilms' tumor, cervical carcinomas, testicular carcinomas, soft-tissue sarcomas, chronic lymphocytic leukemia, primary macroglobulinemia, bladder carcinomas, chronic granulocytic leukemia, primary brain carcinomas, malignant melanoma, small-cell lung carcinomas, stomach carcinomas, colon carcinomas, malignant pancreatic insulinoma, malignant carcinoid carcinomas, malignant melanomas, choriocarcinomas, mycosis fungoides, head and neck carcinomas, osteogenic sarcoma, pancreatic carcinomas, acute granulocytic leukemia, hairy cell leukemia, neuroblastoma, rhabdomyosarcoma, Kaposi's sarcoma, genitourinary carcinomas, thyroid carcinomas, esophageal carcinomas, malignant hypercalcemia, cervical hyperplasia, renal cell carcinomas, endometrial carcinomas, polycythemia vera, essential thrombocytosis, adrenal cortex carcinomas, skin cancer, or prostatic carcinomas. Alternatively, the disease may be an inflammatory disease. The compound may be identified by determining whether the compound binds specifically to an AIP. The AIP may be a transferrin receptor protein, a clathrate heavy chain protein, an IQ motif containing GTPase activating protein, or a heat shock protein.

**[0015]** The invention also relates to the discovery that AIPs are useful for screening for other apoptotic inducing agents. Such screening can employ one or more AIPs, one or more nucleotides which encode AIPs, or one or more nucleotides which hybridize to the nucleotides which encode AIPs, and combinations thereof.

[0016] In another embodiment, the invention pertains to a method of identifying potentially therapeutic anticancer compounds comprising: (a) contacting an AIP with one or more test compounds; and (b) monitoring whether the one or more test compounds binds to the AIP; wherein compounds which bind the AIP are potentially therapeutic anticancer compounds. The AIP may be a transferrin receptor protein, a clathrate heavy chain protein, an IQ motif containing GTPase activating protein, or a heat shock protein.

[0017] In this embodiment, the AIP may be a Transferrin Receptor Related Apoptosis Inducing Protein (TRRAIP), a Clathrin Heavy Chain Related Apoptosis Inducing Protein (CHCRAIP), an IQ motif containing GTPase Activating Protein Related Apoptosis Inducing Protein (IQGAPRAIP), or a Heat Shock Protein Related Apoptosis Inducing Protein (HSPRAIP).

[0018] The invention also pertains to the use of partially or fully purified AIPs which may be used in homogenous or heterogenous binding assays to screen a large number or library of compounds and compositions for their potential ability to induce apoptosis. Those compositions capable of binding to an AIP are potentially useful for inducing apoptosis in vivo. AIPs can be synthesized or isolated from cells which over express these polypeptides. Accordingly, the invention also relates to nucleotides that encode for AIPs; vectors comprising these nucleotides; and cells comprising these vectors.

[0019] In another embodiment of the invention, determining whether the compound binds specifically to an AIP may comprise a competitive or noncompetitive homogeneous assay. The homogeneous assay may be a fluorescence polarization assay or a radioassay. Alternatively, determining whether the compound binds specifically to an AIP may comprise a competitive heterogeneous assay. The heterogeneous assay may be a fluorescence assay, a radioassay or an assay comprising avidin and biotin. The AIP may comprise a detectable label. The label on the AIP may be selected from the group consisting of a fluorescent label and a radiolabel. Alternatively, the gambogic acid or a gambogic acid-related compound may

comprise a detectable label. The label on the gambogic acid or a gambogic acid-related compound may be selected from the group consisting of a fluorescent label and a radiolabel.

**[0020]** The invention also pertains to cells with altered levels of expression of one or more AIPs which may be used in cell-based screening assays to screen a large number or library of compounds and compositions for their ability to induce apoptosis. Such screening assays may be performed with intact cells and afford the identification of potentially therapeutic antineoplastic compositions. In one embodiment, cells have altered levels of expression of one or more AIPs by use of antisense nucleotides or RNA interference. In another embodiment, cells have reduced levels of expression of one or more AIPs by modifying or knocking out the genes in cellular genomic or mitochondrial DNA encoding the AIP(s). In another embodiment, vectors are introduced into the cells thereby elevating levels of expression of one or more AIPs. In another embodiment, cellular genomic or mitochondrial DNA is modified thereby elevating levels of expression of one or more AIPs. In a further embodiment, an AIP binding compound is determined in cell-based screening by i) introducing a compound to a cell having an altered level of expression of one or more AIPs; and ii) monitoring the extent to which the compound induces apoptosis by measuring observable changes in reporter compounds' response to the caspase cascade. Hence, in another embodiment of the invention, the AIP may be present in cells in vitro.

**[0021]** The invention also relates to the use of gambogic acid (or a GA-related compound) for raising antibodies which can be used to screen chemical libraries for other compositions that bind one or more AIPs, or that activate apoptosis. Accordingly, in another embodiment, the invention pertains to a method of identifying potentially therapeutic anticancer compounds comprising: (a) contacting an antibody to gambogic acid (GA) or a GA-related compound; and (b) determining whether the compound binds to the antibody; wherein compounds which bind the antibody are potentially therapeutic anticancer compounds.



**[0022]** In another embodiment, the invention pertains to a method of prognosing the efficacy of an anti-cancer AIP binding composition in a cancer patient comprising: (a) taking a fluid or tissue sample from an individual manifesting a cancer; (b) quantifying the total mRNA encoding one or more AIPs; (c) calculating a ratio comprising the quantity of the mRNA to the average quantity of the mRNA in a population not manifesting the cancer; wherein a ratio greater than 1 indicates that the anti-cancer AIP binding composition is efficacious.

**[0023]** In another embodiment, the invention pertains to a method of prognosing the efficacy of an anti-cancer AIP binding composition in a cancer patient comprising: (a) taking a fluid or tissue sample from an individual manifesting a cancer; (b) quantifying the one or more AIPs present in the sample; (c) calculating a ratio comprising the quantity of the one or more AIPs to the average quantity of the one or more AIPs in a population not manifesting the cancer; wherein a ratio greater than 1 indicates that the anti-cancer AIP binding composition is efficacious.

**[0024]** The invention also relates to the use of the structures of AIPs to design compositions that bind these polypeptides, or to design compositions that activate apoptosis.

**[0025]** Apoptosis may be induced by the compounds of the present invention within 15 minutes to 10 hours of introduction to the cell, or administration to an animal. Apoptosis may also be induced by such compounds within 0.5, 0.75, 1, 2, 3, 4, 5, 6, 7, 8, or 9 hours. These compounds preferably have a molecular weight ranging from 200 Daltons (g/mole) to 20,000 Daltons (g/mole). The compounds may also have a molecular weight ranging from 500 Daltons to 10,000 Daltons.

**[0026]** The invention also relates to a complex, comprising: i) an AIP; and ii) an AIP binding compound; with the proviso that the AIP binding compound is not GA or a GA-related compound.

**[0027]** The invention also relates to a detectably labeled gambogic acid or gambogic acid related compound comprising i) gambogic acid or a gambogic

acid related compound; ii) optionally a linker; and iii) a label; wherein said gambogic acid or said gambogic acid related compound is covalently linked to said label optionally via said linker. The linker may be N,N-(1,2-aminoethyl); N,N-(2-{2-[2-(2-aminoethoxy)-ethoxy]-ethoxy}-aminoethyl); N,N-(2-[2-(2-aminoethoxy)-ethoxy]-aminoethyl); N,N-[2-(2-{2-[2-(2-aminoethoxy)-ethoxy]-ethylcarbamoyl}-ethylthio)-aminoethyl]; N,N-(amidoacetamido); N-[(5-{2-[2-(2-aminoethoxy)-ethoxy]-ethylcarbamoyl}-pentyl)-carboxamide]; N-({5-[2-(2-aminoethylthio)-ethylcarbamoyl]-pentyl})-carboxamide; N,N-[(5-aminopentyl)-thioureidyl]; or N-({2-[2-(2-aminoethoxy)-ethoxy]-ethyl}-carboxamide). The detectable label may be biotin, a fluorescent label, or a radiolabel.

**[0028]** The invention also relates to a composition comprising i) gambogic acid or a gambogic acid related compound; ii) optionally a linker; and iii) a solid phase; wherein said gambogic acid or said gambogic acid related compound is covalently linked to said solid phase optionally via said linker. The solid phase may be amino-agarose or N-hydroxysuccinimidylcarboxylagarose. The composition may be prepared by bonding N-hydroxysuccinimidylgambogate to said solid phase.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0029]** Figs 1A-1D Gambogic acid (GA) binding to transferrin receptor (TR) (SEQ ID NO. 1).

**[0030]** Fig. 1A. GA binds transferrin receptor in vitro. 96-well plates were coated with soluble human transferrin receptor (shTR) (SEQ ID NO. 1) at 375 ng/well and blocked with Bovine Serum Albumin (BSA). Wells were incubated with increasing concentrations of biotin-GA in binding/washing buffer for 20 min at 30°C. Eu-streptavidin was used for the detection. Amounts of bound Eu-Streptavidin were quantified by measuring time-delayed fluorescence. Confirmed in three independent experiments.

**[0031]** Fig. 1B. IC<sub>50</sub> of active and inactive GA derivatives. In competition experiments, biotin-GA at 3.16 μM was pre-mixed with increasing amounts of

GA or the inactive-GA as competitor. Amounts of bound Eu-Streptavidin were quantified by measuring time-delayed fluorescence. Confirmed in three independent experiments.

[0032] Fig. 1C. GA bound to transferrin receptor (SEQ ID NO. 1) *in vitro* can be displaced by active GA derivatives. shTR-coated wells were incubated with biotin-GA as described, washed and incubated with GA or binding/washing buffer as a wash off control. Separate control wells were probed with biotinylated holo-transferrin (bio-Trn) to control for TR retention and possible denaturation over long incubation times. Independently confirmed in three experiments.

[0033] Fig. 1D. Binding of Biotin-GA and tritium-GA to transferrin receptor (SEQ ID NO. 1) is not inhibited by either apo-transferrin or holo-transferrin. Binding of Biotin-GA and tritium-GA to Jurkat cells (hatched) or in-vitro TfR-binding (solid) in the presence of 1  $\mu$ M GA, 50  $\mu$ g/ml of apo-transferrin or 50  $\mu$ g/ml of holo-transferrin is shown in this graph. Confirmed in three independent experiments.

[0034] Figs. 2A and 2B. Gambogic acid (GA) interferes with transferrin receptor (SEQ ID NO. 1) internalization.

[0035] Fig. 2A. GA interferes with receptor internalization as monitored by soluble transferrin internalization. T47D cells were treated with DMSO or 2  $\mu$ M GA for 10 min (panels A and C respectively) and DMSO or 2  $\mu$ M GA for 30 min (panels B and D, respectively) and further treated with FITC conjugated anti-transferrin receptor for 30 mins at 37°C. The cells were then fixed with methanol at -20°C for 5 min, washed with PBS and mounted with Vectashield mounting medium. Representative of three independently confirmed experiments.

[0036] Fig. 2B. GA interferes with transferrin receptor (SEQ ID NO. 1) internalization as indicated by cell surface transferrin receptor expression. Jurkat cells were treated with holo-transferrin (50  $\mu$ g/ml) or GA (5  $\mu$ M) alone for 5 min or pretreat for 5 min with holo-transferrin followed by 5 min GA (5  $\mu$ M) treatment. Cells were then stained with FITC-conjugated anti-

transferrin receptor antibody for 30 minutes at 4°C. After washing, cells were analyzed on a Becton Dickinson FACS Calibur. Data is shown as mean fluorescence units (mfu). Confirmed in three independent experiments.

[0037] Figs. 3A-3C. Down-regulation of the transferrin receptor (SEQ ID NO. 1) using siRNA technology leads to a decrease in apoptosis with gambogic acid treatment.

[0038] Fig. 3A. Realtime PCR showing the down-regulation of the TfR (SEQ ID NO. 1) at the mRNA level. 293T cells were transfected for 48h as untransfected, lipid alone, cph (50nM), and TfR siRNA (50nM). TfR mRNA levels were normalized to cyclophilin, a housekeeping gene. Cyclophilin downregulation was normalized to GAPD. Confirmed in three independent experiments.

[0039] Fig. 3B. Western blot representing the down-regulation of transferrin receptor (SEQ ID NO. 1) in siRNA transfected cells. Whole cell lysates of 293 T cells post transfection were subjected to SDS-PAGE and immunoblotted onto PVDF. Anti-TfR antibody was used to detect the levels of transferrin receptor representing the duplicate samples in the upper panel. Equal loading was confirmed by western blotting of actin (lower panel).

[0040] Fig. 3C. Down regulation of TfR (SEQ ID NO. 1) protects cells from GA-induced apoptosis. 293T cells were plated onto glass cover slips in a 24 well plate and transfected with TfR siRNA (50 nM) for 48 h. Post-transfection, cells were treated with DMSO or 1  $\mu$ M GA for 5 h. Cells were fixed with 3% para-formaldehyde, stained with DAPI at 0.1 $\mu$ g/ml and mounted with Vectashield mounting medium. Quantification of death, post TfR down regulation and GA treatment, was assessed by determining the mean number of cells with fragmented nuclei in 3 representative 20X fields. Independently confirmed in three experiments.

[0041] Figs. 4A-4C Signaling pathway of GA-induced apoptosis.

[0042] Fig. 4A. Western blots representing the apoptosis inducers. Jurkat cells at  $5 \times 10^6$  /ml were treated with DMSO or GA (5  $\mu$ M) for the times indicated. Lysates were subject to SDS PAGE analysis then blotted onto

PVDF membrane. Membranes were probed with anti-caspase 3, anti-caspase 8, Bid, or Cytochrome c antibodies and detected using enhanced chemiluminescence (ECL).

[0043] Figs. 4B. Jurkat cells cultured at  $5 \times 10^6$  /ml were treated with FK19 (Fluoromethyl Ketone), biotinylated caspase inhibitor ( $10 \mu\text{M}$ ) for 30min followed by treatment with DMSO or GA ( $5 \mu\text{M}$ ) for 1hr. Lysates were mixed with  $100 \mu\text{l}$  of streptavidin-agarose beads for 2 hr or overnight at  $4^\circ\text{C}$ . Samples were subject to SDS-PAGE analysis and blotted onto PVDF membrane. Membranes were probed with anti-caspase 8 and detected by ECL.

[0044] Fig. 4C. Downregulation of caspase 8 decreases caspase activation. 293 T cells were transfected with caspase 8 siRNA ( $50\text{nM}$ ) for 48h. Controls used were untransfected and lipid alone. Post-transfection, cells were treated with  $2\mu\text{M}$  GA for 5h. Cell viability was measured by PI staining using flow cytometry.

## DETAILED DESCRIPTION OF THE INVENTION

### I. Definitions

[0045] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art to which this invention belongs.

[0046] As used herein, apoptosis is a highly conserved, genetically programmed form of cellular suicide characterized by distinct morphological changes such as cytoskeletal disruption, cell shrinkage, membrane blebbing, nuclear condensation, fragmentation of DNA, and loss of mitochondrial function.

[0047] As used herein, a caspase is a cysteine protease of the interleukin- $1\beta$ /CED-3 family. As used herein, the caspase cascade is a sequential activation of at least two caspases, or the activation of caspase activity that behaves as if it involves the sequential activation of at least two caspases.

**[0048]** As used herein, "Apoptosis Inducing Proteins" and "AIPs" are used interchangeably and refer to Transferrin Receptor Related Apoptosis Inducing Proteins (TRRAIPs), Clathrin Heavy Chain Related Apoptosis Inducing Proteins (CHCRAIPs), IQ motif containing GTPase Activating Protein Related Apoptosis Inducing Proteins (IQGAPRAIPs), and Heat Shock Protein Related Apoptosis Inducing Proteins (HSPRAIPs). As used herein, an "AIP binding compound" is used to refer to TRRAIP binding compounds, CHCRAIP binding compounds, IQGAPRAIP binding compounds and HSPRAIP binding compounds.

**[0049]** As used herein, "Transferrin Receptor Related Apoptosis Inducing Proteins" and "TRRAIPs" are used interchangeably and refer to SEQ ID NO: 1 or 4, their mutants, homologs, derivatives and fragments which affect apoptosis upon binding gambogic acid (GA) or GA-related compounds such as those described herein or in U.S. Patent No. 6,462,041. Methods for determining whether a given TRRAIP binds to GA or GA-related compounds can be determined by the assays described herein. As used herein, the term "TRRAIP binding compound" refers to a compound which binds specifically to a TRRAIP, induces activation of the caspase cascade, and can be administered in the method of treating, preventing or ameliorating a disease responsive to induction of the caspase cascade in an animal, such as a hyperproliferative disease. As used herein, the term "test compound" refers to a compound that can be tested for its ability to bind an AIP or a TRRAIP. Test compounds identified as capable of binding TRRAIP are TRRAIP binding compounds.

**[0050]** As used herein, "TR" and "TfR" both refer to transferrin receptor.

**[0051]** As used herein, "Clathrin Heavy Chain Related Apoptosis Inducing Proteins" and "CHCRAIPs" are used interchangeably and refer to SEQ ID NO:34, its mutants, homologs, derivatives and fragments which affect apoptosis upon binding gambogic acid (GA) or GA-related compounds such as those described herein or in U.S. Patent No. 6,462,041. Methods for determining whether a given CHCRAIP binds to GA or GA-related

compounds can be determined by the assays described herein. As used herein, the term "CHCRAIP binding compound" refers to a compound which binds specifically to an CHCRAIP, induces activation of the caspase cascade, and can be administered in the method of treating, preventing or ameliorating a disease responsive to induction of the caspase cascade in an animal, such as a hyperproliferative disease. As used herein, the term "test compound" refers to a compound that can be tested for its ability to bind an AIP or a CHCRAIP. Test compounds identified as capable of binding CHCRAIP are CHCRAIP binding compounds.

**[0052]** As used herein, "IQ motif containing GTPase Activating Protein Related Apoptosis Inducing Proteins" and "IQGAPRAIPs" are used interchangeably and refer to SEQ ID NO: 36, its mutants, homologs, derivatives and fragments which affect apoptosis upon binding gambogic acid (GA) or GA-related compounds such as those described herein or in U.S. Patent No. 6,462,041. Methods for determining whether a given IQGAPRAIP binds to GA or GA-related compounds can be determined by the assays described herein. As used herein, the term "IQGAPRAIP binding compound" refers to a compound which binds specifically to an IQGAPRAIP, induces activation of the caspase cascade, and can be administered in the method of treating, preventing or ameliorating a disease responsive to induction of the caspase cascade in an animal, such as a hyperproliferative disease. As used herein, the term "test compound" refers to a compound that can be tested for its ability to bind an AIP or an IQGAPRAIP. Test compounds identified as capable of binding IQGAPRAIP are IQGAPRAIP binding compounds.

**[0053]** As used herein, "Heat Shock Protein Related Apoptosis Inducing Proteins" and "HSPRAIPs" are used interchangeably and refer to SEQ ID NO: 38, its mutants, homologs, derivatives and fragments which affect apoptosis upon binding gambogic acid (GA) or GA-related compounds such as those described herein or in U.S. Patent No. 6,462,041. Methods for determining whether a given HSPRAIP binds to GA or GA-related compounds can be determined by the assays described herein. As used herein, the term

"HSPRAIP binding compound" refers to a compound which binds specifically to a HSPRAIP, induces activation of the caspase cascade, and can be administered in the method of treating, preventing or ameliorating a disease responsive to induction of the caspase cascade in an animal, such as a hyperproliferative disease. As used herein, the term "test compound" refers to a compound that can be tested for its ability to bind an AIP or an HSPRAIP. Test compounds identified as capable of binding HSPRAIP are HSPRAIP binding compounds.

[0054] The test compounds may be pure substances or mixtures of substances such as in combinatorial libraries. The test compounds may be any natural product, synthesized organic or inorganic molecule, or biological macromolecules. Preferably, the test compounds are preselected to have <500 MW,  $\leq 5$  H-bond donors,  $\leq 10$  H-bond acceptors, and  $\log P < 5$ . Computer programs may be used to diversify the compound library. The test compounds may be at least 85% pure.

[0055] As used herein, substantially pure means sufficiently homogeneous to appear free of readily detectable impurities as determined by standard methods of analysis, such as thin layer chromatography (TLC), gel electrophoresis and high performance liquid chromatography (HPLC), used by those of skill in the art to assess such purity, or sufficiently pure such that further purification would not detectably alter the physical and chemical properties, such as enzymatic and biological activities, of the substance. Methods for purification of the compounds to produce substantially chemically pure compounds are known to those of skill in the art. A substantially chemically pure compound, however, may be a mixture of stereoisomers. In such instances, further purification might increase the specific activity of the compound.

[0056] As used herein, a disease which is "responsive to induction of the caspase cascade" is a disease which may be treated with an AIP binding compound. Non-limiting examples of such diseases include hyperproliferative and inflammatory diseases. As used herein, hyperproliferative diseases include any disease characterized by inappropriate cell proliferation. Such



hyperproliferative diseases include skin diseases such as psoriasis, as well as cancer. Non limiting examples of inflammatory diseases include autoimmune diseases such as rheumatoid arthritis, multiple sclerosis, insulin-dependent diabetes mellitus, lupus and muscular dystrophy.

**[0057]** As used herein, a cell which expresses a cancer phenotype includes cells which are characteristic of cancer. Such cells may have come from animals manifesting a cancer, from animal bone, tissue or fluid manifesting a cancer, or from cancer cell lines well known in the art.

**[0058]** As used herein, cancer is a group of diseases characterized by the uncontrolled growth and spread of abnormal cells or one in which compounds that activate the caspase cascade have therapeutic use. Such diseases include, but are not limited to, Hodgkin's disease, non-Hodgkin's lymphomas, acute and chronic lymphocytic leukemias, multiple myeloma, neuroblastoma, breast carcinomas, ovarian carcinomas, lung carcinomas, Wilms' tumor, cervical carcinomas, testicular carcinomas, soft-tissue sarcomas, chronic lymphocytic leukemia, primary macroglobulinemia, bladder carcinomas, chronic granulocytic leukemia, primary brain carcinomas, malignant melanoma, small-cell lung carcinomas, stomach carcinomas, colon carcinomas, malignant pancreatic insulinoma, malignant carcinoid carcinomas, malignant melanomas, choriocarcinomas, mycosis fungoides, head and neck carcinomas, osteogenic sarcoma, pancreatic carcinomas, acute granulocytic leukemia, hairy cell leukemia, neuroblastoma, rhabdomyosarcoma, Kaposi's sarcoma, genitourinary carcinomas, thyroid carcinomas, esophageal carcinomas, malignant hypercalcemia, cervical carcinomas, cervical hyperplasia, renal cell carcinomas, endometrial carcinomas, polycythemia vera, essential thrombocytosis, adrenal cortex carcinomas, skin cancer, and prostatic carcinomas.

**[0059]** As used herein an effective amount of a compound for treating a particular disease is an amount that is sufficient to ameliorate, or in some manner reduce, the symptoms associated with the disease. Such amount may be administered as a single dosage or may be administered according to a

regimen, whereby it is effective. The amount may cure the disease but, typically, is administered in order to ameliorate the disease. Typically, repeated administration is required to achieve the desired amelioration of symptoms.

**[0060]** As used herein, treatment means any manner in which the symptoms of a condition, disorder or disease are ameliorated or otherwise beneficially altered.

**[0061]** As used herein, amelioration of the symptoms of a particular disorder by administration of a particular pharmaceutical composition refers to any lessening, whether permanent or temporary, lasting or transient, that can be attributed to or associated with administration of the composition.

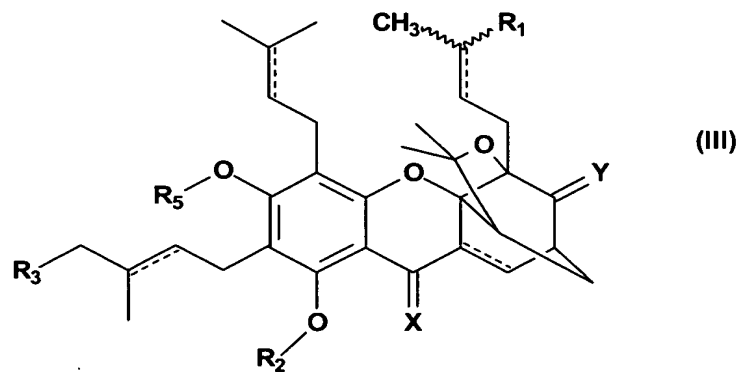
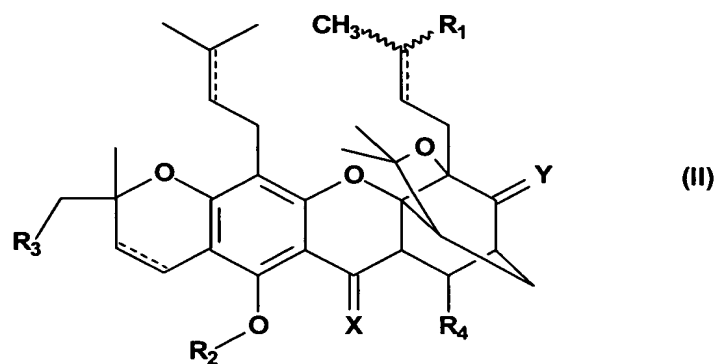
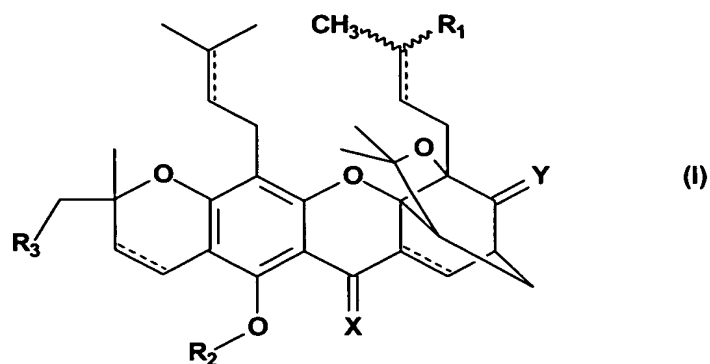
**[0062]** As used herein, EC<sub>50</sub> refers to a dosage, concentration or amount of a particular compound that elicits a dose-dependent response at 50% of maximal expression of a particular response that is induced, provoked or potentiated by the particular compound.

**[0063]** As used herein, a prodrug is a compound that, upon *in vivo* administration, is metabolized or otherwise converted to the biologically, pharmaceutically or therapeutically active form of the compound. To produce a prodrug, the pharmaceutically active compound is modified such that the active compound will be regenerated by metabolic processes. The prodrug may be designed to alter the metabolic stability or the transport characteristics of a drug, to mask side effects or toxicity, to improve the flavor of a drug or to alter other characteristics or properties of a drug. By virtue of knowledge of pharmacodynamic processes and drug metabolism *in vivo*, those of skill in this art, once a pharmaceutically active compound is known, can design prodrugs of the compound (see, e.g., Nogrady, *Medicinal Chemistry: A Biochemical Approach*, Oxford University Press, New York, pages 388-392 (1985)). For example, succinylsulfathiazole is a prodrug of 4-amino-*N*-(2-thiazoyl)benzenesulfonamide (sulfathiazole) that exhibits altered transport characteristics.

[0064] Examples of prodrugs of the compounds of the invention include the simple esters of carboxylic acid containing compounds (e.g. those obtained by condensation with a C<sub>1-4</sub> alcohol according to methods known in the art); esters of hydroxy containing compounds (e.g. those obtained by condensation with a C<sub>1-4</sub> carboxylic acid, C<sub>3-6</sub> dioic acid or anhydride thereof (e.g. succinic and fumaric anhydrides according to methods known in the art); imines of amino containing compounds (e.g. those obtained by condensation with a C<sub>1-4</sub> aldehyde or ketone according to methods known in the art); and acetals and ketals of alcohol containing compounds (e.g. those obtained by condensation with chloromethyl methyl ether or chloromethyl ethyl ether according to methods known in the art).

[0065] As used herein, biological activity refers to the *in vivo* activities of a compound or physiological responses that result upon *in vivo* administration of a compound, composition or other mixture. Biological activity, thus, encompasses therapeutic effects and pharmaceutical activity of such compounds, compositions, and mixtures.

[0066] Gambogic acid and GA-related compounds as used herein include those compounds represented by Formulae I-III:



or pharmaceutically acceptable salts or prodrugs thereof, wherein:

the dotted lines are single bonds, double bonds or an epoxy group;

X together with the attached carbon is a methylene, carbonyl, hydroxymethinyl, alkoxymethinyl, aminomethinyl, an oxime, a hydrazone, an arylhydrazone or semicarbazone;

Y together with the attached carbon is a methylene, carbonyl, hydroxymethinyl, alkoxymethinyl, aminomethinyl, an oxime, a hydrazone, an arylhydrazone or semicarbazone;

R<sub>1</sub> is formyl, methylenehydroxy, carboxy, acyl (R<sub>a</sub>CO), optionally substituted alkoxy carbonyl (R<sub>a</sub>OCO), optionally substituted alkylthiocarbonyl, optionally substituted aminocarbonyl (carbamyl, R<sub>b</sub>R<sub>c</sub>NCO) or hydroxyaminocarbonyl, where R<sub>a</sub> is hydrogen, optionally substituted lower alkyl, optionally substituted aryl, optionally substituted lower aralkyl group or N-succinimidyl; R<sub>b</sub>, and R<sub>c</sub> are independently hydrogen, optionally substituted heteroalkyl, optionally substituted lower alkyl, optionally substituted aryl, optionally substituted heteroaryl or optionally substituted lower aralkyl groups; or R<sub>b</sub>, and R<sub>c</sub> may be taken together with the attached N to form an optionally substituted, saturated or partially saturated 5-7 membered heterocyclo group, including piperidine, morpholine and piperazine;

R<sub>2</sub> is hydrogen, optionally substituted alkyl, acyl (R<sub>a</sub>CO), carbamyl (R<sub>b</sub>R<sub>c</sub>NCO) or sulfonyl (R<sub>d</sub>SO<sub>2</sub>), where R<sub>a</sub>, R<sub>b</sub> and R<sub>c</sub> are defined above; R<sub>d</sub> is hydrogen, optionally substituted lower alkyl, optionally substituted aryl, or optionally substituted lower aralkyl groups;

R<sub>3</sub> is hydrogen or prenyl;

R<sub>4</sub> is hydrogen, halogen, hydroxy, optionally substituted alkyl, cycloalkyl, alkoxy, alkylthio or amino; and

R<sub>5</sub> is hydrogen, optionally substituted alkyl or acyl (R<sub>a</sub>CO), carbamyl (R<sub>b</sub>R<sub>c</sub>NCO) or sulfonyl (R<sub>d</sub>SO<sub>2</sub>), where R<sub>a</sub>, R<sub>b</sub>, R<sub>c</sub> and R<sub>d</sub> are defined above.

[0067] Gambogic acid and GA-related compounds as used herein also include such compounds having the above ring structure described in U.S. Patent No. 6,462,041. Gambogic acid and GA-related compounds as used herein also include the following:

Methyl gambogate;

9,10-Dihydrogambogic acid;

9,10-Dihydrogambogyl(4-methylpiperazine);

9,10-Dihydrogambogyl(2-dimethylaminoethylamine);

Gambogyl diethylamine;  
Gambogyl dimethylamine;  
Gambogyl amine;  
Gambogyl hydroxyamine;  
Gambogyl piperidine;  
6-Methoxy-gambogic acid;  
6-(2-dimethylaminoethoxy)-gambogic acid;  
6-(2-piperidinylethoxy)-gambogic acid;  
6-(2-morpholinylethoxy)-gambogic acid;  
6-Methoxy-gambogyl piperidine;  
Gambogyl morpholine;  
Gambogyl (2-dimethylaminoethylamine);  
10-Morpholinyl-gambogyl morpholine;  
10-Morpholinyl-gambogyl piperidine;  
10-(4-methylpiperazinyl)-gambogyl piperidine;  
10-(4-methylpiperazinyl)-gambogyl morpholine;  
10-Piperidinyl-gambogyl piperidine;  
10-(4-methylpiperazinyl)-gambogyl (4-methylpiperazine);  
Gambogyl (4-methylpiperazine);  
Methyl-6-Methoxy-gambogate;  
Gambogenic acid;  
Gambogenin;  
10-Methoxy-gambogic acid;  
10-Butylthio-gambogic acid;  
10-(4-Methylpiperazinyl)-gambogic acid;  
10-Pyrrolidinyl-gambogic acid;  
Methyl-10-Morpholinyl-gambogate;  
10-Piperidinyl-gambogic acid;  
10-Morpholinyl-gambogic acid;  
N-(2-Gambogylamidoethyl)biotinamide;  
Gambogyl (2-morpholinylethylamine);

9,10-Epoxygambogic acid;  
Gambogyl (4-(2-pyridyl)piperazine);  
10-(4-(2-Pyridyl)piperazinyl)gambogyl (4-(2-pyridyl)piperazine);  
6-Acetylgambogic acid;  
10-(4-(2-Pyridyl)piperazinyl)gambogic acid;  
N-Hydroxysuccinimidyl gambogate;  
8-(Gambogylamido)octanoic acid;  
6-(Gambogylamido)hexanoic acid;  
12-(Gambogylamido)dodecanoic acid;  
N-Hydroxysuccinimidyl-8-(gambogylamido)octanoate;  
N-Hydroxysuccinimidyl-6-(gambogylamido)hexanoate;  
N-Hydroxysuccinimidyl-12-(gambogylamido)dodecanoate;  
10-Methoxy-gambogyl piperidine;  
Gambogyl (4-(2-pyrimidyl)piperazine);  
Gambogyl (bis(2-pyridylmethyl)amine);  
Gambogyl (N-(3-pyridyl)-N-(2-hydroxybenzyl)amine);  
Gambogyl (4-benzylpiperazine);  
Gambogyl (4-(3,4-methylenedioxybenzyl)piperazine);  
Gambogyl (N-methyl-5-(methylamino)-3-oxapentylamine);  
Gambogyl (N-methyl-8-(methylamino)-3,6-dioxaoctylamine);  
Gambogyl (N-ethyl-2-(ethylamino)ethylamine);  
Gambogyl (4-isopropylpiperazine);  
Gambogyl (4-cyclopentylpiperazine);  
Gambogyl (N-(2-oxo-2-ethoxyethyl)-(2-pyridyl)methylamine);  
Gambogyl (2,5-dimethylpiperazine);  
Gambogyl (3,5-dimethylpiperazine);  
Gambogyl (4-(4-acetylphenyl)piperazine);  
Gambogyl (4-ethoxycarbonylpiperazine);  
Gambogyl (4-(2-oxo-2-pyrrolidylethyl)piperazine);  
Gambogyl (4-(2-hydroxyethyl)piperazine);  
Gambogyl (N-methyl-2-(methylamino)ethylamine);

Gambogyl (N-methyl-2-(benzylamino)ethylamine);  
Gambogyl (N-methyl-(6-methyl-2-pyridyl)methylamine);  
Gambogyl (N-ethyl-2-(2-pyridyl)ethylamine);  
Gambogyl (N-methyl-(2-pyridyl)methylamine);  
Gambogyl (N-methyl-4-(3-pyridyl)butylamine);  
Gambogyl (bis(3-pyridylmethyl)amine);  
Gambogyl (2,4-dimethyl-2-imidazoline);  
Gambogyl (4-methyl-homopiperazine);  
Gambogyl (4-(5-hydroxy-3-oxapentyl)piperazine);  
Gambogyl (3-dimethylaminopyrrolidine);  
Gambogyl ((2-furanyl)methylamine);  
Gambogyl (2-hydroxy-1-methyl-2-phenylethylamine);  
Gambogyl (3,4,5-trimethoxybenzylamine);  
Gambogyl (2-(2-methoxyphenyl)ethylamine);  
Gambogyl (2-methoxybenzylamine);  
Gambogyl (3,4-methylenedioxybenzylamine);  
Gambogyl (2-(2,5-dimethoxyphenyl)ethylamine);  
Gambogyl (2-(3-methoxyphenyl)ethylamine);  
Gambogyl (3-(piperidiny)propylamine);  
Gambogyl (2-(piperidiny)ethylamine);  
Gambogyl (3,4-dimethoxybenzylamine);  
Gambogyl ((2-tetrahydrofuranyl)methylamine);  
Gambogyl ((N-ethyl-2-pyrrolidinyl)methylamine);  
Gambogyl (2-diethylaminoethylamine);  
Gambogyl (2,2-dimethyl-3-dimethylaminopropylamine);  
Gambogyl ((N-ethoxycarbonyl-4-piperidiny)amine);  
Gambogyl (2-carbamylpyrrolidine);  
Gambogyl (3-(homopiperidiny)propylamine);  
Gambogyl ((N-benzyl-4-piperidiny)amine);  
Gambogyl (2-(4-methoxyphenyl)ethylamine);  
Gambogyl (4-oxa-hex-5-enylamine);



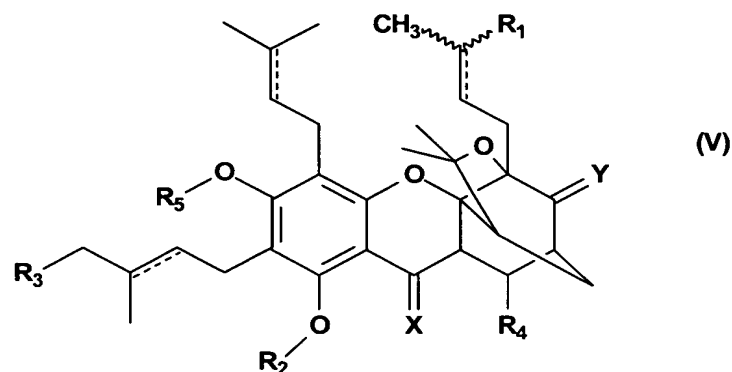
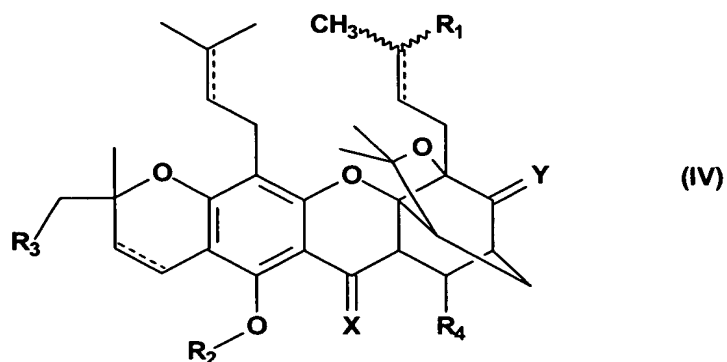
Gambogyl (6-hydroxyhexylamine);  
Gambogyl (2-(3,5-dimethoxyphenyl)ethylamine);  
9,10-Dihydro-12-hydroxygambogic acid;  
Gambogyl 4-morpholine;  
10-Cyclohexyl-gambogic acid;  
10-Methyl-gambogic acid;  
Gambogyl (2-(4-morpholinyl)ethylamine);  
Isogambogic acid;  
Morellinol;  
Morellic acid;  
Desoxymorellin;  
Isomorellinol;  
Isomorellin;  
Morellin-dimethylacetal;  
Isomoreollin B;

The derivative of Isomoreollin B wherein R<sub>4</sub> of Formula II above is ethoxy (instead of methoxy, as in Isomoreollin B);

Moreollic acid (9,10-dihydro-10-methoxy-morellic acid);  
Isogambogenin;  
Desoxygambogenin;  
Gambogenin dimethylacetal;  
Gambogellic acid;  
Hanburin;  
Gambogin;  
Morellin;  
Moreollin;  
Desoxyisomorellin;  
Dihydroisomorellin;  
Ethoxydihydroisomorellin;  
Isomorellic acid;  
Neo-gambogic acid;

Forbesione;  
Gaudichaudiones A-H;  
Gaudichaudic Acids A-E;  
Methyl gambogate ester;  
9,10-Dihydro-10-morpholinyl-gambogyl morpholine;  
9,10-Dihydro-10-morpholinyl-gambogyl piperidine;  
9,10-Dihydro-10-(4-methylpiperazinyl)-gambogyl piperidine;  
9,10-Dihydro-10-(4-methylpiperazinyl)-gambogyl morpholine;  
9,10-Dihydro-10-piperidinyl-gambogyl piperidine;  
9,10-Dihydro-10-(4-methylpiperazinyl)-gambogyl (4-methylpiperazine);  
10-Cyclohexyl-9,10-dihydrogambogic acid;  
9,10-Dihydro-10-methyl gambogic acid;  
9,10-Dihydro-10-methoxy-gambogic acid;  
10-Butylthio-9,10-dihydrogambogic acid;  
9,10-Dihydro-10-(4-methylpiperazinyl)-gambogic acid;  
9,10-Dihydro-10-pyrrolidinyl-gambogic acid;  
Methyl-9,10-dihydro-10-morpholinyl-gambogate;  
9,10-Dihydro-10-piperidinyl-gambogic acid;  
9,10-Dihydro-10-morpholinyl-gambogic acid;  
N-(2-Gambogylamido-ethyl)biotinamide;  
Gambogyl (2-(4-morpholinyl)ethylamine);  
9,10-Dihydro-10-(4-(2-pyridyl)piperazinyl)gambogyl (4-(2-pyridyl)piperazine);  
9,10-Dihydro-10-(4-(2-pyridyl)piperazinyl)gambogic acid;  
9,10-Dihydro-10-methoxy-gambogyl piperidine;  
9,10-Dihydrogambogyl (dimethylamino)ethylamine;  
Gambogyl (3,5-dimethoxybenzylamine); and  
Gambogyl (2-carbamyl-2-(4-hydroxyphenyl)ethylamine).

[0068] Gambogic acid (GA) and GA-related compounds also include those compounds represented by Formulae IV and V:



or pharmaceutically acceptable salts or prodrugs thereof, wherein:

the dotted lines are single bonds, double bonds or an epoxy group;

$X$  together with the attached carbon is a methylene, carbonyl, hydroxymethinyl, alkoxymethinyl, aminomethinyl, an oxime, a hydrazone, an arylhydrazone or semicarbazone;

$Y$  together with the attached carbon is a methylene, carbonyl, hydroxymethinyl, alkoxymethinyl, aminomethinyl, an oxime, a hydrazone, an arylhydrazone or semicarbazone;

$R_1$  is formyl, methylenehydroxy, carboxy, acyl ( $R_aCO$ ), optionally substituted alkoxy carbonyl ( $R_aOCO$ ), optionally substituted alkylthiocarbonyl, optionally substituted aminocarbonyl (carbamyl,  $R_bR_cNCO$ ) or hydroxyaminocarbonyl, where  $R_a$  is hydrogen, optionally substituted lower alkyl, optionally substituted aryl, or optionally substituted lower aralkyl group;

R<sub>b</sub> and R<sub>c</sub> are independently hydrogen, optionally substituted lower alkyl, optionally substituted aryl, or optionally substituted lower aralkyl groups; or R<sub>b</sub> and R<sub>c</sub> may be taken together with the attached N to form a heterocycle, including piperidine, morpholine and piperazine;

R<sub>2</sub> is hydrogen, optionally substituted alkyl, acyl (R<sub>a</sub>CO), carbamyl (R<sub>b</sub>R<sub>c</sub>NCO) or sulfonyl (R<sub>d</sub>SO<sub>2</sub>), where R<sub>a</sub>, R<sub>b</sub> and R<sub>c</sub> are defined above; R<sub>d</sub> is hydrogen, optionally substituted lower alkyl, optionally substituted aryl, or optionally substituted lower aralkyl groups;

R<sub>3</sub> is hydrogen or prenyl;

R<sub>4</sub> is hydrogen, halogen, hydroxy, optionally substituted alkyl, cycloalkyl, alkoxy, arylalkoxy, aryloxy, heteroaryloxy, alkylthio, arylalkylthio, arylthio, heteroarylthio, or amino; and

R<sub>5</sub> is hydrogen, optionally substituted alkyl or acyl (R<sub>a</sub>CO), carbamyl (R<sub>b</sub>R<sub>c</sub>NCO) or sulfonyl (R<sub>d</sub>SO<sub>2</sub>), where R<sub>a</sub>, R<sub>b</sub>, R<sub>c</sub> and R<sub>d</sub> are defined above.

[0069] GA and GA-related compounds also include, without limitation:

9,10-Dihydro-10-morpholinyl-gambogyl (*N*-methylpiperazine);

9,10-Dihydro-10-piperidinyl-gambogyl (*N*-methylpiperazine);

9,10-Dihydro-10-[2-(morpholinyl)ethylamino]-gambogyl (*N*-methylpiperazine);

9,10-Dihydro-10-[4-(2-pyridyl)piperazinyl]-gambogyl (*N*-methylpiperazine);

9,10-Dihydro-10-[2-(morpholinyl)ethoxy]-gambogyl (*N*-methylpiperazine);

9,10-Dihydro-10-(2-dimethylaminoethoxy)-gambogyl (*N*-methylpiperazine);

9,10-Dihydro-10-ethoxy-gambogyl piperidine;

9,10-Dihydro-10-morpholinyl-gambogyl (dimethylamine);

Ethyl 9,10-dihydro-10-morpholinyl-gambogate;

Methyl 9,10-dihydro-10-benzyloxy-gambogate;

Methyl 9,10-dihydro-10-(4-acetylpiperazinyl)-gambogate;

Methyl 9,10-dihydro-10-(piperidinyl)-gambogate;

9,10-Dihydro-10-[4-(2-pyridyl)piperazinyl]-gambogyl (diethylamine);  
9,10-Dihydro-10-[4-(2-pyridyl)piperazinyl]-gambogyl (methylamine);  
9,10-Dihydro-10-(morpholinyl)-gambogyl (diethylamine);  
Methyl-9,10-dihydro-10-ethoxy-gambogate;  
9,10-Dihydro-10-ethoxy-gambogic acid;  
9,10-Dihydro-10-ethoxy-gambogyl (diethylamine);  
Ethyl 9,10-dihydro-10-ethoxy-gambogate;  
Methyl 9,10-dihydro-10-(4-methylpiperazinyl)-gambogate;  
Ethyl 9,10-dihydro-10-(piperidinyl)-gambogate;  
Ethyl 9,10-dihydro-10-(4-methylpiperazinyl)-gambogate; and  
Ethyl 9,10-dihydro-10-(4-acetylpiperazinyl)-gambogate.

**[0070]** The positions in gambogic acid and GA-related compounds described herein are numbered according to Asano, J., *et al.*, *Phytochemistry* 41:815-820 (1996), and Lin, L.-J., *et al.*, *Magn. Reson. Chem.* 31:340-347 (1993). The tricyclic ring (shown as part of the ring on the far right of formulae I-V above) is essential for the TfR binding activity of GA. The  $\alpha,\beta$  unsaturated ketone (found in the two rings furthest to the right of formulae I-V above) is also essential for the TfR binding activity of GA.

**[0071]** As used herein in the context of polypeptides, "mutants" include TRRAIPs given by SEQ ID NO: 1 or 4 having one or more amino acid substitutions. Mutants include naturally occurring or artificially generated TRRAIPs. Naturally occurring mutants include TRRAIPs which are encoded by allelic variation in the TRRAIP gene. As used herein in the context of polypeptides, "mutants" also include CHCRAIPs given by SEQ ID NO: 34 having one or more amino acid substitutions. Mutants include naturally occurring or artificially generated CHCRAIPs. Naturally occurring mutants include CHCRAIPs which are encoded by allelic variation in the CHCRAIP gene. As used herein in the context of polypeptides, "mutants" also include IQGAPRAIPs given by SEQ ID NO: 36 having one or more amino acid substitutions. Mutants include naturally occurring or artificially generated IQGAPRAIPs. Naturally occurring mutants include IQGAPRAIPs which are

encoded by allelic variation in the IQGAPRAIP gene. As used herein in the context of polypeptides, "mutants" also include HSPRAIPs given by SEQ ID NO: 38 having one or more amino acid substitutions. Mutants include naturally occurring or artificially generated HSPRAIPs. Naturally occurring mutants include HSPRAIPs which are encoded by allelic variation in the HSPRAIP gene.

**[0072]** As used herein in the context of polypeptides, "homologs" include TRRAIP sequences that are 70% or more homologous to SEQ ID NO: 1 or 4, as measured by the percent identity of the homolog's primary amino acid sequence to that of SEQ ID NO: 1 or 4. For example, a homolog that is only 700 amino acids long is 60 amino acids shorter than SEQ ID NO: 1. However, if 650 amino acids of this homolog have an identical sequential arrangement with respect to SEQ ID NO: 1, then the homolog is about 93% identical ( $((650/700) \times 100\%)$ ) to SEQ ID NO: 1. Preferably, homologs are 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or more homologous to SEQ ID NO: 1 or 4.

**[0073]** As used herein in the context of polypeptides, "homologs" also include CHCRAIP sequences that are 70% or more homologous to SEQ ID NO: 34, as measured by the percent identity of the homolog's primary amino acid sequence to that of SEQ ID NO: 34. For example, a homolog that is only 1000 amino acids long is 675 amino acids shorter than SEQ ID NO: 34. However, if 900 amino acids of this homolog have an identical sequential arrangement with respect to SEQ ID NO: 34, then the homolog is 90% identical ( $((900/1000) \times 100\%)$ ) to SEQ ID NO: 34. Preferably, homologs are 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or more homologous to SEQ ID NO: 34.

**[0074]** As used herein in the context of polypeptides, "homologs" also include IQGAPRAIP sequences that are 70% or more homologous to SEQ ID NO: 36, as measured by the percent identity of the homolog's primary amino acid sequence to that of SEQ ID NO: 36. For example, a homolog that is only 1000 amino acids long is 657 amino acids shorter than SEQ ID NO: 36.

However, if 900 amino acids of this homolog have an identical sequential arrangement with respect to SEQ ID NO: 36, then the homolog is 90% identical  $((900/1000) \times 100\%)$  to SEQ ID NO: 36. Preferably, homologs are 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or more homologous to SEQ ID NO: 36.

**[0075]** As used herein in the context of polypeptides, "homologs" also include HSPRAIP sequences that are 70% or more homologous to SEQ ID NO: 38, as measured by the percent identity of the homolog's primary amino acid sequence to that of SEQ ID NO: 38. For example, a homolog that is only 600 amino acids long is 124 amino acids shorter than SEQ ID NO: 38. However, if 540 amino acids of this homolog have an identical sequential arrangement with respect to SEQ ID NO: 38, then the homolog is 90% identical  $((540/600) \times 100\%)$  to SEQ ID NO: 38. Preferably, homologs are 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or more homologous to SEQ ID NO: 38.

**[0076]** As used herein in the context of polypeptides, "derivatives" refer to TRRAIPs, CHCRAIPs, IQGAPRAIPs and HSPRAIPs that are respectively derivatized or modified forms of SEQ ID NO: 1 or 4, 34, 36 or 38. Such derivatives may include, for example, post-expression modifications, amidated carboxyl groups, glycosylated amino acid residues, and formylated and acetylated amino groups. Such derivatives may also include TRRAIP, CHCRAIP, IQGAPRAIP or HSPRAIP having a leader or secretory sequence, such as a pre-, pro- or prepro- protein sequence; or TRRAIP, CHCRAIP, IQGAPRAIP or HSPRAIP fused to amino acids or other proteins, such as those which provide additional functionalities.

**[0077]** As used herein in the context of polypeptides, "fragments" refer to any oligopeptide or polypeptide which is less than the full length of SEQ ID NO: 1, 4, 34, 36 or 38. Fragments may be 70% or more identical to SEQ ID NO: 1, 4, 34, 36 or 38. Preferably, fragments are 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or more identical to SEQ ID NO: 1, 4, 34, 36 or 38. Fragments may be 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 300, 400, 500, 600, 700 or more contiguous amino acids of SEQ ID NO:

1, 4 or 38. Fragments may also be 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600 or more contiguous amino acids of SEQ ID NO: 34 or 36.

**[0078]** Fragments which are 20 amino acids long (referred to as "20-mers") include amino acids 1-20, 2-21, 3-22, 4-23, 5-24, 6-25, 7-26, 8-27, 9-28, 10-29, 11-30, 12-31, 13-32, 14-33, 15-34, 16-35, 17-36, 18-37, 19-38, 20-39, 21-40, 22-41, 23-42, 24-43, 25-44, 26-45, 27-46, 28-47, 29-48, 30-49, 31-50, 32-51, 33-52, 34-53, 35-54, 36-55, 37-56, 38-57, 39-58, 40-59, 41-60, 42-61, 43-62, 44-63, 45-64, 46-65, 47-66, 48-67, 49-68, 50-69, 51-70, 52-71, 53-72, 54-73, 55-74, 56-75, 57-76, 58-77, 59-78, 60-79, 61-80, 62-81, 63-82, 64-83, 65-84, 66-85, 67-86, 68-87, 69-88, 70-89, 71-90, 72-91, 73-92, 74-93, 75-94, 76-95, 77-96, 78-97, 79-98, 80-99, 81-100, 82-101, 83-102, 84-103, 85-104, 86-105, 87-106, 88-107, 89-108, 90-109, 91-110, 92-111, 93-112, 94-113, 95-114, 96-115, 97-116, 98-117, 99-118, 100-119, 101-120, 102-121, 103-122, 104-123, 105-124, 106-125, 107-126, 108-127, 109-128, 110-129, 111-130, 112-131, 113-132, 114-133, 115-134, 116-135, 117-136, 118-137, 119-138, 120-139, 121-140, 122-141, 123-142, 124-143, 125-144, 126-145, 127-146, 128-147, 129-148, 130-149, 131-150, 132-151, 133-152, 134-153, 135-154, 136-155, 137-156, 138-157, 139-158, 140-159, 141-160, 142-161, 143-162, 144-163, 145-164, 146-165, 147-166, 148-167, 149-168, 150-169, 151-170, 152-171, 153-172, 154-173, 155-174, 156-175, 157-176, 158-177, 159-178, 160-179, 161-180, 162-181, 163-182, 164-183, 165-184, 166-185, 167-186, 168-187, 169-188, 170-189, 171-190, 172-191, 173-192, 174-193, 175-194, 176-195, 177-196, 178-197, 179-198, 180-199, 181-200, 182-201, 183-202, 184-203, 185-204, 186-205, 187-206, 188-207, 189-208, 190-209, 191-210, 192-211, 193-212, 194-213, 195-214, 196-215, 197-216, 198-217, 199-218, 200-219, 201-220, 202-221, 203-222, 204-223, 205-224, 206-225, 207-226, 208-227, 209-228, 210-229, 211-230, 212-231, 213-232, 214-233, 215-234, 216-235, 217-236, 218-237, 219-238, 220-239, 221-240, 222-241, 223-242, 224-243, 225-244, 226-245, 227-246, 228-247, 229-248, 230-249, 231-250,



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[0079] As used herein, "nucleotides" and "polynucleotides" are used interchangeably and refer to single or double stranded polynucleic acid molecules composed of DNA or RNA. The term "nucleotides" includes any polynucleic acid molecule that encodes for SEQ ID NOs: 1, 4, 34, 36 or 38, their mutants, homologs, derivatives and fragments which affect apoptosis upon binding gambogic acid (GA) or GA-related compounds such as those described herein or in U.S. Patent No. 6,462,041. The term "nucleotides" also includes any polynucleic acid molecule which hybridize to a nucleotide which encodes for any one of SEQ ID NOs: 1, 4, 34, 36 or 38, their mutants, homologs, derivatives and fragments which affect apoptosis upon binding gambogic acid (GA) or GA-related compounds such as those described herein or in U.S. Patent No. 6,462,041. Nucleotides encoding for TRRAIPs, CHCRAIPs, IQGAPRAIPs or HSPRAIPs include the respective coding

sequence for the TRRAIP, CHCRAIP, IQGAPRAIP or HSPRAIP polypeptides and optionally additional sequences.

**[0080]** The term "nucleotides" also includes variants. "Variants" refer to one of several alternate forms of a gene occupying a given locus on a chromosome of an organism. Genes II, Lewin, B., ed., John Wiley & Sons, New York (1985). "Variants" also includes non-naturally occurring variants produced using art-known mutagenesis techniques. Variants include those produced by nucleotide substitutions, deletions or additions which may involve one or more nucleotides. The variants may be altered in regions coding for TRRAIP, CHCRAIP, IQGAPRAIP or HSPRAIP, and/or other regions. Alterations in the coding regions may produce conservative or non-conservative amino acid substitutions, deletions or additions. Silent substitutions, additions and deletions which do not alter the properties and activities of the TRRAIP, CHCRAIP, IQGAPRAIP or HSPRAIP, or portions thereof, and conservative substitutions may also be used.

**[0081]** The term "nucleotides" also includes splice variants. "Splice variants" refer to a transcribed RNA in which one or more DNA introns are removed. Hence, the skilled artisan will recognize that any of the nucleotides described herein may have a splice variant. AIPs also include polypeptides encoded by these splice variants.

**[0082]** Nucleotides encoding for AIPs may include, but are not limited to, those encoding the amino acid sequence of the AIPs described herein by themselves. Nucleotides encoding for AIPs also include those encoding an AIP and additional nucleotide sequences. "Additional nucleotide sequences" may include, but are not limited to i) nucleic acid sequences which encode an amino acid leader or secretory sequence, such as a pre-, pro- or prepro- protein sequence; ii) non-coding sequences, including for example, but not limited to introns and non-coding 5' and 3' sequences, such as the transcribed, non-translated sequences that play a role in transcription, mRNA processing, including splicing and polyadenylation signals, for example--ribosome binding and stability of mRNA; and iii) an additional coding sequence which codes for



additional amino acids, such as those which provide additional functionalities. Thus, the nucleotide sequence encoding the AIP may be fused to a marker sequence, such as a sequence encoding a peptide which facilitates purification of the fused polypeptide. In other embodiments of this aspect of the invention, the marker amino acid sequence is a hexa-histidine peptide, such as the tag provided in a pQE vector (Qiagen, Inc.), among others, many of which are commercially available. As described in Gentz et al, Proc. Natl. Acad. Sci. USA 86:821-824 (1989), for instance, hexa-histidine provides for convenient purification of the fusion protein. The "HA" tag is another peptide useful for purification which corresponds to an epitope derived from the influenza hemagglutinin protein, which has been described by Wilson et al, Cell 37:767-778 (1984).

**[0083]** Nucleotides which encode for an AIP may also comprise polynucleotides which hybridize under stringent hybridization conditions to a portion of the polynucleotides described herein, as described in U.S. Patent No. 6,027,916. By a polynucleotide which hybridizes to a "portion" of a polynucleotide is intended a polynucleotide (either DNA or RNA) hybridizing to at least about 15, 20, 30, 40, 50, 60 or 70 nucleotides (nt) of the reference polynucleotide. These are useful as diagnostic probes and primers.

**[0084]** Nucleotides are at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or more identical to the sequences described herein. By a polynucleotide having a nucleotide sequence at least, for example, 95% "identical" to a reference nucleotide sequence encoding an AIP, is intended that the nucleotide sequence of the polynucleotide is identical to the reference sequence except that the polynucleotide sequence may include up to five point mutations per each 100 nucleotides of the reference nucleotide sequence encoding the AIP. In other words, to obtain a polynucleotide having a nucleotide sequence at least 95% identical to a reference nucleotide sequence, up to 5% of the nucleotides in the reference sequence may be deleted or substituted with another nucleotide, or a number of nucleotides up to 5% of the total nucleotides in the reference sequence may be inserted into the

reference sequence. These mutations of the reference sequence may occur at the 5' or 3' terminal positions of the reference nucleotide sequence or anywhere between those terminal positions, interspersed either individually among nucleotides in the reference sequence or in one or more contiguous groups within the reference sequence.

**[0085]** As a practical matter, whether any particular nucleic acid molecule is at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or more identical to a nucleotide sequences described herein can be determined conventionally using known computer programs such as the Bestfit program. Wisconsin Sequence Analysis Package, Version 8 for Unix, Genetics Computer Group, University Research Park, 575 Science Drive, Madison, Wis. 53711. Bestfit uses the local homology algorithm of Smith and Waterman, *Advances in Applied Mathematics* 2:482-489 (1981), to find the best segment of homology between two sequences. When using Bestfit or any other sequence alignment program to determine whether a particular sequence is, for instance, 95% identical to a reference sequence according to the present invention, the parameters are set such that the percentage of identity is calculated over the full length of the reference nucleotide sequence and that gaps in homology of up to 5% of the total number of nucleotides in the reference sequence are allowed.

**[0086]** Of course, due to the degeneracy of the genetic code, one of ordinary skill in the art will immediately recognize that a large number of the nucleic acid molecules having a sequence at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or more identical to the nucleic acid sequences described herein will encode an AIP. In fact, since degenerate variants of these nucleotide sequences all encode the same polypeptide, this will be clear to the skilled artisan even without performing the above described comparison assay. It will be further recognized in the art that, for such nucleic acid molecules that are not degenerate variants, a reasonable number will also encode AIPs. This is because the skilled artisan is fully aware of amino acid substitutions that are either less likely or not likely to significantly effect

protein function. For example, replacing one aliphatic amino acid with a second aliphatic amino acid is not likely to alter AIP function. Guidance concerning how to make phenotypically silent amino acid substitutions is provided in Bowie, J. U. *et al.*, "Deciphering the Message in Protein Sequences: Tolerance to Amino Acid Substitutions," *Science* 247:1306-1310 (1990), wherein the authors indicate that proteins are surprisingly tolerant of amino acid substitutions.

**[0087]** As used herein, a cell which "up regulates" an AIP is a cell with an elevated level of AIP as compared to normal cells or cells which down regulate AIP. The manner by which a cell up regulates AIP is described below and includes, for example, an altered AIP gene or AIP promoter, or a transfection vector that encodes AIP. As used herein, a cell which "down regulates" AIP is a cell with a reduced level of AIP as compared to normal cells or as compared to cells which up regulate AIP. The manner by which a cell down regulates AIP is described below and includes, for example, an altered AIP gene or AIP promoter, antisense mRNA, or RNAi. As used herein, a "normal" cell neither up regulates or down regulates AIP. Hence, a normal cell does not have an altered AIP gene or AIP promoter, a transfection vector encoding AIP, antisense mRNA or RNAi. Elevated levels of AIP include increased levels of functional AIP. Reduced levels of AIP includes reduced levels of expressed *or* reduced levels of functional AIP. Normal cells have less functional AIP than cells which up regulate AIP; and more functional AIP than cells which down regulate AIP.

**[0088]** As used herein, a subinducing amount of a substance is an amount that is sufficient to produce a measurable change in caspase cascade activity when used in the method of the present invention and which produces a greater measurable change in caspase cascade activity when used in synergistic combination with an AIP binding compound in the method of the present invention.

**[0089]** "Label" is used herein to refer to any atom or molecule that is detectable and can be attached to a protein or test compound of interest.

Examples of labels include, but are not limited to, radiolabels, fluorescent labels, phosphorescent labels, chemiluminescent labels and magnetic labels. Any label known in the art can be used in the present invention. As used herein, "homogenous assays" refer to assays in which all components are mixed together in the same phase. One example of a homogenous assay is where the components mixed together are all in solution. In contrast, "heterogenous assays" refer to assays in which a first component is attached to a solid phase such as a bead or other solid substrate and one or more additional components are in solution.

[0090] As used herein, the term "fluorophore" or "fluorescent group" means any conventional chemical compound, which when excited by light of suitable wavelength, will emit fluorescence with high quantum yield. See, for example, J. R. Lakowicz in "Principles of Fluorescence Spectroscopy," Plenum Press, 1983. Numerous known fluorophores of a wide variety of structures and characteristics are suitable for use in the practice of this invention. In choosing a fluorophore for fluorescence polarization assays, it is preferred that the lifetime of the fluorophore's excited state be long enough, relative to the rate of motion of the labeled test compound, to permit measurable loss of polarization following emission. Typical fluorescing compounds, which are suitable for use in the present invention, include, for example, rhodamine, substituted rhodamine, fluorescein, fluorescein isothiocyanate, naphthofluorescein, dichlorotriazinylamine fluorescein, dansyl chloride, phycoerythrin, and umbelliferone. Other suitable fluorescent groups for use in the present invention include, but are not limited to, those described in U.S. Patent Nos. 4,255,329, 4,668,640 and 5,315,015.

[0091] As used herein, the term "reporter molecule" is synonymous with the term "reporter compound" and the two terms are used interchangeably. A reporter molecule is a fluorogenic, chromogenic or chemiluminescent substrate that produces a signal such as fluorescence, light absorption within the ultraviolet, visible or infrared spectrum, or light emission, under the influence of the caspase cascade.

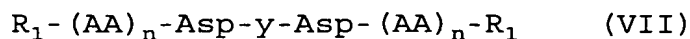
**[0092]** The reporter molecule may be composed of at least two covalently linked parts. One part is an amino acid sequence which may be recognized by any of the intracellular proteases or peptidases that are produced as a result of caspase cascade activation. This sequence is bonded to an aromatic or conjugated moiety that undergoes a detectable physical change upon its release from all or part of the amino acid sequence. Such moieties include a fluorogenic moiety that fluoresces more strongly after the reporter molecule is hydrolyzed by one of the proteases, a chromogenic moiety that changes its light absorption characteristics after the reporter molecule is hydrolyzed by one of the proteases, or a chemiluminescent moiety that produces light emission after the reporter molecule is hydrolyzed by one of the proteases. Alternatively, the aromatic or conjugated moiety may be linked to a plurality of amino acid sequences.

**[0093]** One type of such a reporter molecule is given by Formula VI:



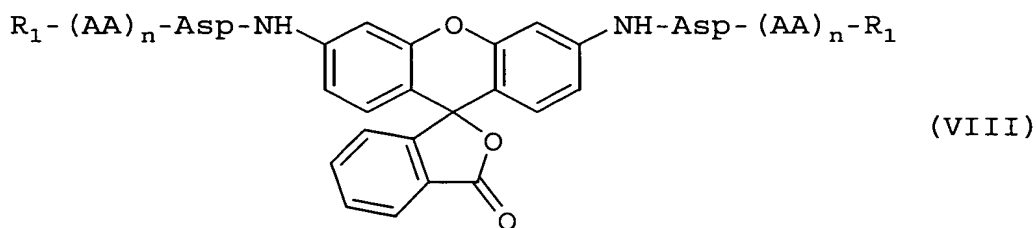
or biologically acceptable salts or pro-reporter molecules (such as methyl ester form of carboxyl-containing amino acid residues) thereof, wherein x and z is the same or different and is a peptide or amino acid or acyl group or other structure such that compounds of Formula VI are substrates for a caspase or other enzyme involved in the intracellular apoptosis cascade; and wherein the scissile bond is only one or both of the x-y and y-z bonds in Formula VI when x is the same as z, or wherein the scissile bond is only one of the x-y or y-z bond in Formula VI when x is not the same as z. y is a fluorogenic or fluorescent moiety. See U.S. Pat. No. 6,342,611.

**[0094]** Particular reporter compounds are represented by Formula VII:



or biologically acceptable salts or pro-reporter molecules (such as methyl ester form of carboxyl-containing amino acid residues) thereof, wherein  $R_1$  is an N-terminal protecting group such as t-butyloxycarbonyl, acetyl, and benzyloxycarbonyl; each AA independently is a residue of any natural or non-natural  $\alpha$ -amino acid or  $\beta$ -amino acid, or derivatives of an  $\alpha$ -amino acid or  $\beta$ -amino acid; each n is independently 0-5; and y is a fluorogenic or fluorescent moiety. y may be a Rhodamine including Rhodamine 110, Rhodamine 116 and Rhodamine 19.

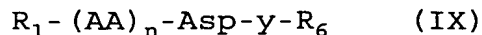
[0095] Other particular reporter compounds are represented by Formula VIII:



or biologically acceptable salts or pro-reporter molecules (such as methyl ester form of carboxyl-containing amino acid residues) thereof, wherein  $R_1$ , AA, n are as defined previously in Formula VII.  $R_1$  may be t-butyloxycarbonyl, acetyl and benzyloxycarbonyl. Values of n are 1-3.

[0096] Another group of compounds falling within the scope of Formula VI include compounds wherein x is not the same as z. Particular compounds of this group include those wherein x is a peptide or other structure which makes the compound a substrate for a caspase or other enzyme related to apoptosis, and the x-y bond in Formula VI is the only bond which is scissile under biological conditions. z is a blocking group and the y-z bond in Formula VI is not a scissile bond under biological conditions.

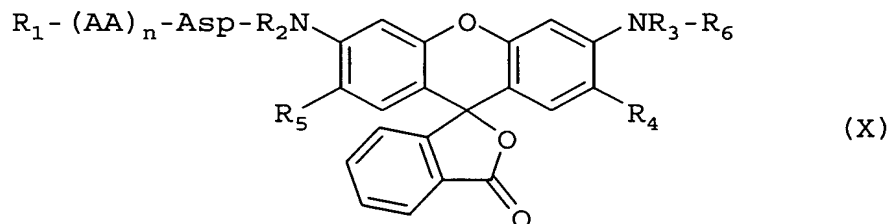
[0097] Specifically, the fluorogenic or fluorescent reporter compounds that may be used in this invention are of Formula IX:



or biologically acceptable salts or pro-reporter molecules (such as methyl ester form of carboxyl-containing amino acid residues) thereof, wherein:  $R_1$ , AA, n and y are as defined previously in Formula VII; and  $R_6$  is a blocking group which is not an amino acid or a derivative of an amino acid.

[0098] Particular  $R_6$  blocking groups include, but are not limited to, an alkyloxycarbonyl group such as methoxycarbonyl, an arylalkyloxycarbonyl group such as benzyloxycarbonyl, a  $C_{2-6}$  acyl (alkanoyl) group such as acetyl, a carbamyl group such as dimethylcarbamyl, and an alkyl, haloalkyl or aralkyl sulfonyl group such as methanesulfonyl. Particular y is a Rhodamine including Rhodamine 110, Rhodamine 116 and Rhodamine 19.

[0099] In other embodiments, the reporter compounds are represented by Formula X:



or biologically acceptable salts or pro-reporter molecules (such as methyl ester form of carboxyl-containing amino acid residues) thereof, wherein  $R_1$ ,  $R_6$ , AA and n are as defined previously in Formula VII;  $R_2$  and  $R_3$  are the same or different and are independently hydrogen, alkyl or aryl; and  $R_4$  and  $R_5$  are the same or different and are independently hydrogen or alkyl.

[00100]  $R_1$  may be t-butyloxycarbonyl, acetyl and benzyloxycarbonyl. Values of n may be 1-3.  $R_2$  and  $R_3$  may be hydrogen, methyl or ethyl.  $R_4$  and  $R_5$  may be hydrogen or methyl.  $R_6$  blocking groups include, but are not limited to, an alkyloxycarbonyl group such as methoxycarbonyl, an arylalkyloxycarbonyl group such as benzyloxycarbonyl, an acyl group such as acetyl, a carbamyl group such as dimethylcarbamyl, and an alkyl, haloalkyl or aralkyl sulfonyl group such as methanesulfonyl.

[00101] Example of reporter molecules which are useful for the screening methods of the present invention include *N*-(Ac-DEVD)-*N'*-acetyl-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-ethoxycarbonyl-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-hexyloxycarbonyl-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-octyloxycarbonyl-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-decyloxycarbonyl-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-dodecyloxycarbonyl-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-2-butoxyethoxycarbonyl-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-(ethylthio)carbonyl-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-(hexylthio)carbonyl-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-(octylthio)carbonyl-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-(*N*-hexyl-*N*-methylcarbamyl)-Rhodamine 110 (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-(2,3,4,5,6-pentafluorobenzoyl)-Rhodamine (SEQ ID NO.: 41), *N*-(Ac-DEVD)-*N'*-(2,3,4,5-tetrafluorobenzoyl)-Rhodamine (SEQ ID NO.: 41) and others disclosed in U.S. patent no. 6,342,611, 6,335,429 and 6,248,904. Since they are relatively small in size and lipophilic at the same time, many of these substrates can be used in the assays of the invention in the absence of a permeabilization enhancer.

[00102] Other useful reporter molecules include Ac-DEVD-*p*NA (SEQ ID NO.: 41), Ac-DEVD-AMC (SEQ ID NO.: 41), MCA-DEVDAPK(DNP)-OH (SEQ ID NO.: 42), Z-DEVD-AFC (SEQ ID NO.: 41), MCA-VDQMDGW[K-DNP]-NH<sub>2</sub> (SEQ ID NO.: 43), MCA-DEVDAR[K-DNP]-NH<sub>2</sub> (SEQ ID NO.: 44), Z-VDVAD-AFC (SEQ ID NO.: 45), MCA-VDVADGW[K-DNP]-NH<sub>2</sub> (SEQ ID NO.: 46), MCA-VDQVDGW[K-DNP]-NH<sub>2</sub> (SEQ ID NO.: 47), Ac-VEID-*p*NA (SEQ ID NO.: 48), Ac-VEID-AMC (SEQ ID NO.: 48), Z-VEID-AFC (SEQ ID NO.: 48) and MCA-VQVDGW[K-DNP]-NH<sub>2</sub> (SEQ ID NO.: 49), (CALBIOCHEM, California).

[0100] Other fluorogenic reporter molecules useful in the practice of the present invention are disclosed in the following United States patents: 4,336,186; 4,557,862; 4,640,893; 5,208,148; 5,227,487; 5,362,628; 5,443,986; 5,556,992; 5,587,490; 5,605,809; 5,698,411; 5,714,342; 5,733,719; 5,776,720,



5,849,513; 5,871,946; 5,897,992; 5,908,750; 5,976,822. Useful reporter molecules are also described in EP 0285179 B1; EP 623599 A1; WO 93/04192; WO 93/10461; WO 96/20721; WO 96/36729; WO 98/57664; Ganesh, S. *et al.*, *Cytometry* 20:334-340 (1995); Haugland, R. and Johnson, I., *J. Fluorescence* 3:119-127 (1993); Haugland, R., *Biotechnic and Histochemistry* 70:243-251 (1995); Haugland, R., *Molecular Probes Handbook of Fluorescent Probes and Research Chemicals*, pp. 28 and 54, 6th Ed. (1996); Holskin, B., *et al.*, *Anal. Biochem.* 226:148-155 (1995); Johnson, A., *et al.*, *Anal. Chem.* 65:2352-2359 (1993); Klingel, S., *et al.*, *Methods in Cell Biology* 41:449-459 (1994); Leytus, S., *et al.*, *Biochem. J.* 215:253-260 (1983); Leytus, S., *et al.*, *Biochem. J.* 209:299-307 (1983); Matayoshi, E., *et al.*, *Science* 247:954-958 (1990); Morliere, P., *et al.*, *Biochem. Biophys. Res. Commun.* 146:107-113 (1987); O'Boyle, D., *et al.*, *Virology* 236:338-347 (1997); Richards, A., *et al.*, *J. Biol. Chem.* 265:7733-7736 (1990); Rothe, G., *et al.*, *Biol. Chem. Hoppe-Seyler* 373:547-554 (1992); Stevens, J., *et al.*, *Eur. J. Biochem.* 226:361-367 (1994); Tamburini, P., *et al.*, *Anal. Biochem.* 186:363-368 (1990); Thornberry, N., *et al.*, *J. Biol. Chem.* 272:17907-17911 (1997); Toth, M. and Marshall, G., *Int. J. Peptide Protein Res.* 36:544-550 (1990); Tyagi, S. and Carter, C., *Anal. Biochem.* 200:143-148 (1992); Weber, J. "Adenovirus Endopeptidase and Its Role in Virus Infection" in *The Molecular Repertoire of Adenoviruses I*, Doerfler, W. and Bohm, P. eds., pp. 227-235, Springer Press, New York (1995); Zhang, R., *et al.*, *J. Virology* 71:6208-6213 (1997); Mangel, W., *et al.*, *Biol. Chem. Hoppe-Seyler* 373:433-440 (1992); Bonneau, P., *et al.*, *Anal. Biochem.* 255:59-65 (1998); and DiIanni, C., *et al.*, *J. Biol. Chem.* 268:25449-25454 (1993).

[0101] As used herein, the abbreviations for any protective groups, amino acids, and other compounds, are, unless indicated otherwise, in accord with their common usage, or recognized abbreviations.

## II. Therapeutic Methods

[0102] One embodiment of the invention relates to compounds which bind one or more AIPs and induce activation of apoptosis. Another embodiment of the invention relates to pharmaceutical formulations of these compounds, and methods of administration of compositions comprising these compounds for preventing, treating or ameliorating a disease responsive to induction of the caspase cascade in an animal. Another embodiment of the invention pertains to a method of treating, preventing or ameliorating a disease in an animal comprising administering to the animal a composition comprising a compound which binds specifically to an AIP.

[0103] The present invention includes a therapeutic method useful to modulate *in vivo* apoptosis or *in vivo* neoplastic disease, comprising administering to a subject in need of such treatment an effective amount of one or more AIP binding compounds, or a pharmaceutically acceptable salt or prodrug of one or more AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis.

[0104] The present invention also includes a therapeutic method comprising administering to an animal an effective amount of one or more AIP binding compounds, or a pharmaceutically acceptable salt or prodrug of one or more AIP binding compounds, wherein the therapeutic method is useful to treat cancer, which is a group of diseases characterized by the uncontrolled growth and spread of abnormal cells.

[0105] In practicing the therapeutic methods, effective amounts of compositions containing therapeutically effective concentrations of the AIP binding compounds formulated for oral, intravenous, local and topical application (for the treatment of neoplastic diseases and other diseases in which caspase cascade mediated physiological responses are implicated), are administered to an individual exhibiting the symptoms of one or more of these disorders. The amounts are effective to ameliorate or eliminate one or more symptoms of the disorder. An effective amount of an AIP binding compound

for treating a particular disease is an amount that is sufficient to ameliorate, or in some manner reduce, the symptoms associated with the disease. Such amount may be administered as a single dosage or may be administered according to a regimen, whereby it is effective. The amount may cure the disease but, typically, is administered in order to ameliorate the disease. Typically, repeated administration is required to achieve the desired amelioration of symptoms.

**[0106]** In another embodiment, a pharmaceutical composition comprising an AIP binding compound, or a pharmaceutically acceptable salt of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis in combination with a pharmaceutically acceptable vehicle, is provided.

**[0107]** Another embodiment of the present invention is directed to a composition effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known cancer chemotherapeutic agent, or a pharmaceutically acceptable salt of the agent. Examples of known anti-cancer agents which can be used for combination therapy include, but are not limited to alkylating agents, such as busulfan, cisplatin, mitomycin C, and carboplatin; antimitotic agents, such as colchicine, vinblastine, paclitaxel, and docetaxel; topo I inhibitors, such as camptothecin and topotecan; topo II inhibitors, such as doxorubicin and etoposide; RNA/DNA antimetabolites, such as 5-azacytidine, 5-fluorouracil and methotrexate; DNA antimetabolites, such as 5-fluoro-2'-deoxy-uridine, ara-C, hydroxyurea and thioguanine; and antibodies, such as Herceptin<sup>®</sup> and Rituxan<sup>®</sup>. Other known anti-cancer agents, which can be used for combination therapy, include arsenic trioxide, gemcitabine, melphalan, chlorambucil, cyclophosphamide, ifosfamide, vincristine, mitoguanzone, epirubicin, aclarubicin, bleomycin, mitoxantrone, elliptinium, fludarabine, octreotide, retinoic acid, tamoxifen and alanosine.

[0108] In practicing the methods of the present invention, the AIP binding compound of the invention may be administered together with the at least one known chemotherapeutic agent as part of a unitary pharmaceutical composition. Alternatively, the AIP binding compound of the invention may be administered apart from the at least one known cancer chemotherapeutic agent. In this embodiment, the AIP binding compound of the invention and the at least one known cancer chemotherapeutic agent are administered substantially simultaneously, i.e. the AIP binding compounds are administered at the same time or one after the other, so long as the AIP binding compounds reach therapeutic levels for a period of time in the blood.

[0109] It has been reported that alpha-1-adrenoceptor antagonists, such as doxazosin, terazosin, and tamsulosin can inhibit the growth of prostate cancer cell via induction of apoptosis (Kyprianou, N., *et al.*, *Cancer Res* 60:4550-4555, (2000)). Therefore, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known alpha-1-adrenoceptor antagonists, or a pharmaceutically acceptable salt of the agent. Examples of known alpha-1-adrenoceptor antagonists, which can be used for combination therapy include, but are not limited to, doxazosin, terazosin, and tamsulosin.

[0110] It has been reported that sigma-2 receptors are expressed in high densities in a variety of tumor cell types (Vilner, B. J., *et al.*, *Cancer Res.* 55: 408-413 (1995)) and that sigma-2 receptor agonists, such as CB-64D, CB-184 and haloperidol activate a novel apoptotic pathway and potentiate antineoplastic drugs in breast tumor cell lines. (Kyprianou, N., *et al.*, *Cancer Res.* 62:313-322 (2002)). Therefore, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein,

which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known sigma-2 receptor agonists, or a pharmaceutically acceptable salt of the agent. Examples of known sigma-2 receptor agonists, which can be used for combination therapy include, but are not limited to, CB-64D, CB-184 and haloperidol.

[0111] It has been reported that combination therapy with lovastatin, a HMG-CoA reductase inhibitor, and butyrate, an inducer of apoptosis in the Lewis lung carcinoma model in mice, showed potentiating antitumor effects (Giermasz, A., *et al.*, *Int. J. Cancer* 97:746-750 (2002)). Therefore, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known HMG-CoA reductase inhibitor, or a pharmaceutically acceptable salt of the agent. Examples of known HMG-CoA reductase inhibitors, which can be used for combination therapy include, but are not limited to, lovastatin, simvastatin, pravastatin, fluvastatin, atorvastatin and cerivastatin.

[0112] It has been reported that synthetic retinoids, such as fenretinide (*N*-(4-hydroxyphenyl)retinamide, 4HPR), have good activity in combination with other chemotherapeutic agents, such as cisplatin, etoposide or paclitaxel in small-cell lung cancer cell lines (Kalemkerian, G. P., *et al.*, *Cancer Chemother. Pharmacol.* 43:145-150 (1999)). 4HPR also was reported to have good activity in combination with gamma-radiation on bladder cancer cell lines (Zou, C., *et al.*, *Int. J. Oncol.* 13:1037-1041 (1998)). Therefore, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known retinoid and synthetic retinoid, or a pharmaceutically acceptable salt of the agent. Examples of

known retinoids and synthetic retinoids, which can be used for combination therapy include, but are not limited to, bexarotene, tretinoin, 13-cis-retinoic acid, 9-cis-retinoic acid,  $\alpha$ -difluoromethylornithine, ILX23-7553, fenretinide, and *N*-4-carboxyphenyl retinamide.

[0113] It has been reported that proteasome inhibitors, such as lactacystin, exert anti-tumor activity *in vivo* and in tumor cells *in vitro*, including those resistant to conventional chemotherapeutic agents. By inhibiting NF-kappaB transcriptional activity, proteasome inhibitors may also prevent angiogenesis and metastasis *in vivo* and further increase the sensitivity of cancer cells to apoptosis (Almond, J. B., *et al.*, *Leukemia* 16:433-443 (2002)). Therefore, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known proteasome inhibitor, or a pharmaceutically acceptable salt of the agent. Examples of known proteasome inhibitors, which can be used for combination therapy include, but are not limited to, lactacystin, MG-132, and PS-341.

[0114] It has been reported that tyrosine kinase inhibitors, such as STI571 (Imatinib mesilate, Gleevec), have potent synergetic effect in combination with other anti-leukemic agents, such as etoposide (Liu, W.M., *et al. Br. J. Cancer* 86:1472-1478 (2002)). Therefore, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known tyrosine kinase inhibitor, or a pharmaceutically acceptable salt of the agent. Examples of known tyrosine kinase inhibitors, which can be used for combination therapy include, but are not limited to, gleevec, ZD1839 (Iressa), SH268, genistein, CEP2563, SU6668, SU11248, and EMD121974.

[0115] It has been reported that prenyl-protein transferase inhibitors, such as farnesyl protein transferase inhibitor R115777, possess preclinical antitumor activity against human breast cancer (Kelland, L.R., *et al.*, *Clin. Cancer Res.* 7:3544-3550 (2001)). Synergy of the protein farnesyltransferase inhibitor SCH66336 and cisplatin in human cancer cell lines also has been reported (Adjei, A. A., *et al.*, *Clin. Cancer Res.* 7:1438-1445 (2001)). Therefore, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known prenyl-protein transferase inhibitor, including farnesyl protein transferase inhibitor, inhibitors of geranylgeranyl-protein transferase type I (GGPTase-I) and geranylgeranyl-protein transferase type-II, or a pharmaceutically acceptable salt of the agent. Examples of known prenyl-protein transferase inhibitors, which can be used for combination therapy include, but are not limited to, R115777, SCH66336, L-778,123, BAL9611 and TAN-1813.

[0116] It has been reported that cyclin-dependent kinase (CDK) inhibitors, such as flavopiridol, have potent synergetic effect in combination with other anticancer agents, such as CPT-11, a DNA topoisomerase I inhibitor in human colon cancer cells (Motwani, M., *et al.*, *Clin. Cancer Res.* 7:4209-4219, (2001)). Therefore, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known cyclin-dependent kinase inhibitor, or a pharmaceutically acceptable salt of the agent. Examples of known cyclin-dependent kinase inhibitor, which can be used for combination therapy include, but are not limited to, flavopiridol, UCN-01, roscovitine and olomoucine.

[0117] It has been reported that in preclinical studies COX-2 inhibitors were found to block angiogenesis, suppress solid tumor metastases, and slow the growth of implanted gastrointestinal cancer cells (Blanke, C. D., *Oncology (Huntingt)* 16(No. 4 Suppl. 3):17-21 (2002)). Therefore, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known COX-2 inhibitors, or a pharmaceutically acceptable salt of the agent. Examples of known COX-2 inhibitors, which can be used for combination therapy include, but are not limited to, celecoxib, valecoxib, and rofecoxib.

[0118] It has been reported in clinical studies that regular administration of non-steroidal anti-inflammatory drugs (NSAIDs) reduces the risk of breast cancer. See Study: Why aspirin, fiber prevent cancer, posted Wenesday, April 9, 2003 at <http://www.cnn.com/2003/Health/04/09/health.cancer.aspirin.reut/index.html>. It has also been reported that in colon cancer cells, NSAIDs prevent interleukin-6 from activating STAT1; STAT1 prevents cellular suicide. *Id.* Hence, NSAIDs are believed to make cells more conducive to apoptosis. Therefore, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with at least one known NSAID, or a pharmaceutically acceptable salt of the agent. Examples of known NSAIDs, which can be used for combination therapy include, but are not limited to, ibuprofen, aspirin and sulindac.

[0119] Another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising a bioconjugate of an AIP binding compound described herein, which functions



as a caspase cascade activator and inducer of apoptosis, in bioconjugation with at least one known therapeutically useful antibody, such as Herceptin® or Rituxan®, growth factors, such as DGF, NGF; cytokines, such as IL-2, IL-4, or any molecule that binds to the cell surface. The antibodies and other molecules will deliver an AIP binding compound described herein to its targets and make it an effective anticancer agent. The bioconjugates could also enhance the anticancer effect of therapeutically useful antibodies, such as Herceptin® or Rituxan®.

[0120] Similarly, another embodiment of the present invention is directed to compositions and methods effective to inhibit neoplasia comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, in combination with radiation therapy. In this embodiment, the AIP binding compound of the invention may be administered at the same time as the radiation therapy is administered or at a different time.

[0121] Yet another embodiment of the present invention is directed to compositions and methods effective for post-surgical treatment of cancer, comprising an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis. The invention also relates to a method of treating cancer by surgically removing the cancer and then treating the animal with one of the pharmaceutical compositions described herein.

[0122] A wide range of immune mechanisms operate rapidly following exposure to an infectious agent. Depending on the type of infection, rapid clonal expansion of the T and B lymphocytes occurs to combat the infection. The elimination of the effector cells following an infection is one of the major mechanisms maintaining immune homeostasis. This deletion of reactive cells has been shown to be regulated by a phenomenon known as apoptosis. Autoimmune diseases have been lately identified as a consequence of

deregulated cell death. In certain autoimmune diseases, the immune system directs its powerful cytotoxic effector mechanisms against specialized cells, such as oligodendrocytes in multiple sclerosis, the beta cells of the pancreas in diabetes mellitus, and thyrocytes in Hashimoto's thyroiditis (Ohsako, S., *et al.*, *Cell Death Differ.* 6(1):13-21 (1999)). Mutations of the gene encoding the lymphocyte apoptosis receptor Fas/APO-1/CD95 are reported to be associated with defective lymphocyte apoptosis and autoimmune lymphoproliferative syndrome (ALPS), which is characterized by chronic, histologically benign splenomegaly and generalized lymphadenopathy, hypergammaglobulinemia, and autoantibody formation. (Infante, A.J., *et al.*, *J. Pediatr.* 133(5):629-633 (1998) and Vaishnaw, A.K., *et al.*, *J. Clin. Invest.* 103(3):355-363 (1999)). It was reported that overexpression of Bcl-2, which is a member of the Bcl-2 gene family of programmed cell death regulators with anti-apoptotic activity, in developing B cells of transgenic mice, in the presence of T cell dependent costimulatory signals, results in the generation of a modified B cell repertoire and in the production of pathogenic autoantibodies (Lopez-Hoyos, M., *et al.*, *Int. J. Mol. Med.* 1(2):475-483 (1998)). It is therefore, evident that many types of autoimmune disease are caused by defects of the apoptotic process and one treatment strategy would be to turn on apoptosis in the lymphocytes that are causing autoimmune disease (O'Reilly, L.A. & Strasser, A., *Inflamm. Res.* 48(1):5-21 (1999)).

- [0123] Fas-Fas ligand (FasL) interaction is known to be required for the maintenance of immune homeostasis. Experimental autoimmune thyroiditis (EAT), characterized by autoreactive T and B cell responses and a marked lymphocytic infiltration of the thyroid, is a good model to study the therapeutic effects of FasL. Batteux, F., *et al.*, *J. Immunol.* 162(1):603-608 (1999)) reported that by direct injection of DNA expression vectors encoding FasL into the inflamed thyroid, the development of lymphocytic infiltration of the thyroid was inhibited and induction of the death of infiltrating T cells was observed. These results show that FasL expression on thyrocytes may have a

curative effect on ongoing EAT by inducing death of pathogenic autoreactive infiltrating T lymphocytes.

[0124] Bisindolylmaleimide VIII is known to potentiate Fas-mediated apoptosis in human astrocytoma 1321N1 cells and in Molt-4T cells, both of which were resistant to apoptosis induced by anti-Fas antibody in the absence of bisindolylmaleimide VIII. Potentiation of Fas-mediated apoptosis by bisindolylmaleimide VIII was reported to be selective for activated, rather than non-activated, T cells, and was Fas-dependent. (Zhou, T., *et al*, *Nat. Med.* 5(1):42-8 (1999)) reported that administration of bisindolylmaleimide VIII to rats during autoantigen stimulation prevented the development of symptoms of T cell-mediated autoimmune diseases in two models, the Lewis rat model of experimental allergic encephalitis and the Lewis adjuvant arthritis model. Therefore, the application of a Fas-dependent apoptosis enhancer, such as bisindolylmaleimide VIII, may be therapeutically useful for the more effective elimination of detrimental cells and inhibition of T cell-mediated autoimmune diseases. Therefore, an effective amount of an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, should be an effective treatment for autoimmune disease.

[0125] Psoriasis is a chronic skin disease, which is characterized by scaly red patches. Psoralen plus ultraviolet A (PUVA) is a widely used and effective treatment for psoriasis vulgaris and Coven, T.R., *et al.*, *Photodermatol. Photoimmunol. Photomed.* 15(1):22-7 (1999), reported that lymphocytes treated with psoralen 8-MOP or TMP plus UVA displayed DNA degradation patterns typical of apoptotic cell death. Ozawa, M., *et al.*, *J. Exp. Med.* 189(4):711-718 (1999) reported that induction of T cell apoptosis could be the main mechanism by which 312-nm UVB resolves psoriasis skin lesions. Low doses of methotrexate may be used to treat psoriasis to restore a clinically normal skin. Heenen, M., *et al.*, *Arch. Dermatol. Res.* 290(5):240-245 (1998), reported that low doses of methotrexate may induce apoptosis and this mode

of action could explain the reduction in epidermal hyperplasia during treatment of psoriasis with methotrexate. Therefore, an effective amount of an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, should be an effective treatment for psoriasis.

[0126]        Synovial cell hyperplasia is a characteristic of patients with rheumatoid arthritis (RA). Excessive proliferation of RA synovial cells that, in addition, are defective in synovial cell death might be responsible for the synovial cell hyperplasia. Wakisaka, S., *et al.*, *Clin. Exp. Immunol.* 114(1):119-28 (1998), found that, although RA synovial cells could die via apoptosis through Fas/FasL pathway, apoptosis of synovial cells was inhibited by proinflammatory cytokines present within the synovium, and suggested that inhibition of apoptosis by the proinflammatory cytokines may contribute to the outgrowth of synovial cells and lead to pannus formation and the destruction of joints in patients with RA. Therefore, an effective amount of an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, should be an effective treatment for rheumatoid arthritis.

[0127]        There has been an accumulation of convincing evidence that apoptosis plays a major role in promoting resolution of the acute inflammatory response. Neutrophils are constitutively programmed to undergo apoptosis, thus limiting their pro-inflammatory potential and leading to rapid, specific, and non-phlogistic recognition by macrophages and semi-professional phagocytes (Savill, J., *J. Leukoc. Biol.* 61(4):375-80 (1997)). Boirivant, M., *et al.*, *Gastroenterology* 116(3):557-65 (1999), reported that lamina propria T cells isolated from areas of inflammation in Crohn's disease, ulcerative colitis, and other inflammatory states manifest decreased CD2 pathway-induced apoptosis, and that studies of cells from inflamed Crohn's disease tissue, indicate that this defect is accompanied by elevated Bcl-2 levels. Therefore an

effective amount of an AIP binding compound, or a pharmaceutically acceptable salt or prodrug of an AIP binding compound described herein, which functions as a caspase cascade activator and inducer of apoptosis, should be an effective treatment for inflammation.

[0128] Caspase cascade activators and inducers of apoptosis may also be a desirable therapy in the elimination of pathogens, such as HIV, Hepatitis C and other viral pathogens. The long lasting quiescence, followed by disease progression, may be explained by an anti-apoptotic mechanism of these pathogens leading to persistent cellular reservoirs of the virions. It has been reported that HIV-1-infected T leukemia cells or peripheral blood mononuclear cells (PBMCs) underwent enhanced viral replication in the presence of the caspase inhibitor Z-VAD-fmk. Furthermore, Z-VAD-fmk also stimulated endogenous virus production in activated PBMCs derived from HIV-1-infected asymptomatic individuals (Chinnaiyan, A., *et al.*, *Nat. Med.* 3:333 (1997)). Therefore, apoptosis may serve as a beneficial host mechanism to limit the spread of HIV and new therapeutics using caspase/apoptosis activators may be useful to clear viral reservoirs from the infected individuals. Similarly, HCV infection also triggers anti-apoptotic mechanisms to evade the host's immune surveillance leading to viral persistence and hepatocarcinogenesis (Tai, D.I., *et al.* *Hepatology* 3:656-64 (2000)). Therefore, apoptosis inducers may be useful as therapeutics for HIV and other infectious disease.

[0129] Stent implantation has become the new standard angioplasty procedure. However, in-stent restenosis remains the major limitation of coronary stenting. New approaches have been developed to target pharmacological modulation of local vascular biology by local administration of drugs. This allows for drug applications at the precise site and time of vessel injury. Numerous pharmacological agents with antiproliferative properties are currently under clinical investigation, including actinomycin D, rapamycin or paclitaxel coated stents (Regar E., *et al.*, *Br. Med. Bull.* 59:227-

248 (2001)). Therefore, apoptosis inducers, which are antiproliferative, may be useful as therapeutics for in-stent restenosis.

[0130] Compositions within the scope of this invention include all compositions wherein the AIP binding compounds of the present invention are contained in an amount which is effective to achieve its intended purpose. While individual needs vary, determination of optimal ranges of effective amounts of each component is within the skill of the art. Typically, the AIP binding compounds may be administered to mammals, e.g. humans, orally at a dose of 0.0025 to 100 mg/kg, or an equivalent amount of the pharmaceutically acceptable salt thereof, per day of the body weight of the mammal being treated for apoptosis-mediated disorders. The AIP binding compounds may be administered to mammals, e.g. humans, intravenously at a dose of 0.025 to 200 mg/kg, or an equivalent amount of the pharmaceutically acceptable salt thereof, per day of the body weight of the mammal being treated for apoptosis-mediated disorders. Preferably, approximately 0.01 to approximately 50 mg/kg is orally administered to treat or prevent such disorders. For intramuscular injection, the dose is generally approximately one-half of the oral dose. For example, a suitable intramuscular dose would be approximately 0.0025 to approximately 50 mg/kg, and most preferably, from approximately 0.01 to approximately 10 mg/kg. If a known cancer chemotherapeutic agent is also administered, it is administered in an amount which is effective to achieve its intended purpose. The amounts of such known cancer chemotherapeutic agents effective for cancer are well known to those of skill in the art.

[0131] The unit oral dose may comprise from approximately 0.01 to approximately 50 mg, preferably approximately 0.1 to approximately 10 mg of the AIP binding compound of the invention. The unit dose may be administered one or more times daily as one or more tablets, each containing from approximately 0.1 to approximately 10, conveniently approximately 0.25 to 50 mg of the AIP binding compound or its solvates.

[0132] In a topical formulation, the AIP binding compound may be present at a concentration of approximately 0.01 to 100 mg per gram of carrier.

[0133] In addition to administering the AIP binding compound as a raw chemical, the AIP binding compounds of the invention may be administered as part of a pharmaceutical preparation containing suitable pharmaceutically acceptable carriers comprising excipients and auxiliaries, which facilitate processing of the AIP binding compounds into preparations that can be used pharmaceutically. Preferably, the preparations, particularly those preparations, which can be administered orally and which can be used for the preferred type of administration, such as tablets, dragees, and capsules, and also preparations, which can be administered rectally, such as suppositories, as well as suitable solutions for administration by injection or orally, contain from approximately 0.01 to 99 percent, preferably from approximately 0.25 to 75 percent of active AIP binding compound(s), together with the excipient.

[0134] Also included within the scope of the present invention are the non-toxic pharmaceutically acceptable salts of the AIP binding compounds of the present invention. Acid addition salts are formed by mixing a solution of the particular apoptosis inducer of the present invention with a solution of a pharmaceutically acceptable non-toxic acid, such as hydrochloric acid, hydrobromic acid, fumaric acid, maleic acid, succinic acid, acetic acid, citric acid, lactic acid, tartaric acid, carbonic acid, phosphoric acid, sulfuric acid, oxalic acid, and the like. Basic salts are formed by mixing a solution of the particular apoptosis inducer of the present invention with a solution of a pharmaceutically acceptable non-toxic base, such as sodium hydroxide, potassium hydroxide, choline hydroxide, sodium carbonate, Tris, *N*-methyl-glucamine and the like.

[0135] The pharmaceutical compositions of the invention may be administered to any animal, which may experience the beneficial effects of the AIP binding compounds of the invention. Foremost among such animals are mammals, e.g., humans and veterinary animals, although the invention is not intended to be so limited.

[0136] The pharmaceutical compositions of the present invention may be administered by any means that achieve their intended purpose. For example,

administration may be by parenteral, subcutaneous, intravenous, intramuscular, intraperitoneal, transdermal, buccal, intrathecal, intracranial, intranasal or topical routes. Alternatively, or concurrently, administration may be by the oral route. The dosage administered will be dependent upon the age, health, and weight of the recipient, kind of concurrent treatment, if any, frequency of treatment, and the nature of the effect desired.

[0137] The pharmaceutical preparations of the present invention are manufactured in a manner, which is itself known, e.g., by means of conventional mixing, granulating, dragee-making, dissolving, or lyophilizing processes. Thus, pharmaceutical preparations for oral use can be obtained by combining the active AIP binding compounds with solid excipients, optionally grinding the resultant mixture and processing the mixture of granules, after adding suitable auxiliaries, if desired or necessary, to obtain tablets or dragee cores.

[0138] Suitable excipients are, in particular: fillers, such as saccharides, e.g. lactose or sucrose, mannitol or sorbitol; cellulose preparations and/or calcium phosphates, e.g. tricalcium phosphate or calcium hydrogen phosphate; as well as binders, such as starch paste, using, e.g. maize starch, wheat starch, rice starch, potato starch, gelatin, tragacanth, methyl cellulose, hydroxypropylmethylcellulose, sodium carboxymethylcellulose, and/or polyvinyl pyrrolidone. If desired, disintegrating agents may be added, such as the above-mentioned starches and also carboxymethyl-starch, cross-linked polyvinyl pyrrolidone, agar, or alginic acid or a salt thereof, such as sodium alginate. Auxiliaries are, above all, flow-regulating agents and lubricants, e.g. silica, talc, stearic acid or salts thereof, such as magnesium stearate or calcium stearate, and/or polyethylene glycol. Dragee cores are provided with suitable coatings which, if desired, are resistant to gastric juices. For this purpose, concentrated saccharide solutions may be used, which may optionally contain gum arabic, talc, polyvinyl pyrrolidone, polyethylene glycol and/or titanium dioxide, lacquer solutions and suitable organic solvents or solvent mixtures. In order to produce coatings resistant to gastric juices, solutions of suitable



cellulose preparations, such as acetylcellulose phthalate or hydroxypropymethyl-cellulose phthalate, are used. Dye stuffs or pigments may be added to the tablets or dragee coatings, e.g., for identification or in order to characterize combinations of active AIP binding compound doses.

[0139] Other pharmaceutical preparations, which can be used orally, include push-fit capsules made of gelatin, as well as soft, sealed capsules made of gelatin and a plasticizer, such as glycerol or sorbitol. The push-fit capsules can contain the active AIP binding compounds in the form of granules, which may be mixed with fillers, such as lactose, binders such as starches, and/or lubricants such as talc or magnesium stearate and, optionally, stabilizers. In soft capsules, the active AIP binding compounds are preferably dissolved or suspended in suitable liquids, such as fatty oils, or liquid paraffin. In addition, stabilizers may be added.

[0140] Possible pharmaceutical preparations, which can be used rectally include, e.g. suppositories, which consist of a combination of one or more of the active AIP binding compounds with a suppository base. Suitable suppository bases are, e.g. natural or synthetic triglycerides, or paraffin hydrocarbons. In addition, it is also possible to use gelatin rectal capsules, which consist of a combination of the active AIP binding compounds with a base. Possible base materials include, e.g. liquid triglycerides, polyethylene glycols, or paraffin hydrocarbons.

[0141] Suitable formulations for parenteral administration include aqueous solutions of the active AIP binding compounds in water-soluble form, e.g. water-soluble salts and alkaline solutions. In addition, suspensions of the active AIP binding compounds as appropriate oily injection suspensions may be administered. Suitable lipophilic solvents or vehicles include fatty oils, e.g. sesame oil; or synthetic fatty acid esters, e.g. ethyl oleate or triglycerides or polyethylene glycol-400 (the AIP binding compounds may be soluble in PEG-400). Aqueous injection suspensions may contain substances, which increase the viscosity of the suspension include, e.g. sodium carboxymethyl cellulose,

sorbitol, and/or dextran. Optionally, the suspension may also contain stabilizers.

**[0142]** In accordance with one aspect of the present invention, AIP binding compounds of the invention are employed in topical and parenteral formulations and are used for the treatment of skin cancer.

**[0143]** The topical compositions of this invention are formulated preferably as oils, creams, lotions, ointments and the like by choice of appropriate carriers. Suitable carriers include vegetable or mineral oils, white petrolatum (white soft paraffin), branched chain fats or oils, animal fats and high molecular weight alcohol (greater than C<sub>12</sub>). The preferred carriers are those in which the active ingredient is soluble. Emulsifiers, stabilizers, humectants and antioxidants may also be included as well as agents imparting color or fragrance, if desired. Additionally, transdermal penetration enhancers can be employed in these topical formulations. Examples of such enhancers can be found in U.S. Patent Nos. 3,989,816 and 4,444,762.

**[0144]** Creams are preferably formulated from a mixture of mineral oil, self-emulsifying beeswax and water in which mixture the active ingredient, dissolved in a small amount of an oil such as almond oil, is admixed. A typical example of such a cream is one which includes approximately 40 parts water, approximately 20 parts beeswax, approximately 40 parts mineral oil, and approximately 1 part almond oil.

**[0145]** Ointments may be formulated by mixing a solution of the active ingredient in a vegetable oil, such as almond oil with warm soft paraffin and allowing the mixture to cool. A typical example of such an ointment is one which includes approximately 30% almond oil and approximately 70% white soft paraffin by weight.

**[0146]** Also included within the scope of the present invention are dosage forms of the AIP binding compounds, in which the oral pharmaceutical preparations comprise an enteric coating. The term "enteric coating" is used herein to refer to any coating over an oral pharmaceutical dosage form that inhibits dissolution of the active ingredient in acidic media, but dissolves

rapidly in neutral to alkaline media and has good stability to long-term storage. Alternatively, the dosage form having an enteric coating may also comprise a water soluble separating layer between the enteric coating and the core.

[0147] The core of the enterically coated dosage form comprises an AIP binding compound. Optionally, the core also comprises pharmaceutical additives and/or excipients. The separating layer may be a water soluble inert AIP binding compound or polymer for film coating applications. The separating layer is applied over the core by any conventional coating technique known to one of ordinary skill in the art. Examples of separating layers include, but are not limited to sugars, polyethylene glycol, polyvinylpyrrolidone, polyvinyl alcohol, hydroxypropyl cellulose, polyvinyl acetal diethylaminoacetate and hydroxypropyl methylcellulose. The enteric coating is applied over the separating layer by any conventional coating technique. Examples of enteric coatings include, but are not limited to cellulose acetate phthalate, hydroxypropyl methylcellulose phthalate, polyvinyl acetate phthalate, carboxymethylethylcellulose, copolymers of methacrylic acid and methacrylic acid methyl esters, such as Eudragit® L 12,5 or Eudragit® L 100 (Röhm Pharma), water based dispersions such as Aquateric® (FMC Corporation), Eudragit® L 100-55 (Röhm Pharma) and Coating CE 5142 (BASF), and those containing water soluble plasticizers such as Citroflex® (Pfizer). The final dosage form is either an enteric coated tablet, capsule or pellet.

### III. Polypeptide and Polynucleotide Sequences

[0148] This section lists non-limiting examples of AIPs and the corresponding nucleotides which encode these AIPs. The polypeptide and polynucleotide sequences described below in subsections A-H are wholly incorporated by reference herein, and are useful with the screening methods of the present invention.

A. Transferrin Receptor Related Apoptosis Inducing Proteins (TRRAIPs)

**[0149]** Non-limiting examples of TRRAIPs include Transferrin receptor (p90, CD71) [Homo sapiens] (SEQ ID NO: 1) (NCBI Accession No. XP\_052730); Transferrin receptor [Homo sapiens] (SEQ ID NO: 2) (NCBI Accession No. AAF04564); Transferrin receptor (p90, CD71) [Homo sapiens] (SEQ ID NO: 3) (NCBI Accession No. AAH01188); Transferrin receptor (p90, CD 71) [Homo sapiens] (SEQ ID NO: 4) (NCBI Accession No. NP\_003225); Put. transferrin receptor (aa 1-760) [Homo sapiens] (SEQ ID NO: 5) (NCBI Accession No. CAA25527); Transferrin receptor [Homo sapiens] (SEQ ID NO: 6) (NCBI Accession No. AAA61153); Transferrin receptor [Cavia (guinea pigs)] (SEQ ID NO: 7) (NCBI Accession No. AAB35972); Transferrin receptor protein 1 (TfR1) (TR) (TfR) (Trfr) (CD71 antigen) (T9) (p90) [Homo sapiens] (SEQ ID NO: 8) (NCBI Accession No. P02786); Transferrin receptor [Homo sapiens] (SEQ ID NO: 9) (NCBI Accession No. JXHU); Transferrin receptor [Homo sapiens] (SEQ ID NO: 10) (NCBI Accession No. 1011297A); Chain C, Hemochromatosis Protein Hfe Complexed With Transferrin Receptor [Homo sapiens] (SEQ ID NO: 11) (NCBI Accession No. 1DE4\_C); Chain F, Hemochromatosis Protein Hfe Complexed With Transferrin Receptor [Homo sapiens] (SEQ ID NO: 12) (NCBI Accession No. 1DE4\_F); Chain I, Hemochromatosis Protein Hfe Complexed With Transferrin Receptor [Homo sapiens] (SEQ ID NO: 13) (NCBI Accession No. 1DE4\_I); Chain A, Crystal Structure Of The Ectodomain Of Human Transferrin Receptor [Homo sapiens] (SEQ ID NO: 14) (NCBI Accession No. 1CX8\_A); Chain B, Crystal Structure Of The Ectodomain Of Human Transferrin Receptor [Homo sapiens] (SEQ ID NO: 15) (NCBI Accession No. 1CX8\_B); Chain C, Crystal Structure Of The Ectodomain Of Human Transferrin Receptor [Homo sapiens] (SEQ ID NO: 16) (NCBI Accession No. 1CX8\_C); Chain D, Crystal Structure Of The Ectodomain Of Human Transferrin Receptor [Homo sapiens] (SEQ ID NO: 17) (NCBI Accession No. 1CX8\_D); Chain E, Crystal Structure Of The

Ectodomain Of Human Transferrin Receptor [Homo sapiens] (SEQ ID NO: 18) (NCBI Accession No. 1CX8\_E); Chain F, Crystal Structure Of The Ectodomain Of Human Transferrin Receptor [Homo sapiens] (SEQ ID NO: 19) (NCBI Accession No. 1CX8\_F); Chain G, Crystal Structure Of The Ectodomain Of Human Transferrin Receptor [Homo sapiens] (SEQ ID NO: 20) (NCBI Accession No. 1CX8\_G); Chain H, Crystal Structure Of The Ectodomain Of Human Transferrin Receptor [Homo sapiens] (SEQ ID NO: 21) (NCBI Accession No. 1CX8\_H); Transferrin receptor - guinea pig (fragment) [Cavia porcellus (domestic guinea pig)] (SEQ ID NO: 22) (NCBI Accession No. S68317); Transferrin receptor [human, Peptide Partial, 17 aa] [Homo sapiens] (SEQ ID NO: 23) (NCBI Accession No. AAB22984); Transferrin receptor p95, TfR p95 (internal fragment) [human, prostatic-carcinoma cell line DU 145, Peptide Partial, 15 aa, segment 2 of 2] [Homo sapiens] (SEQ ID NO: 24) (NCBI Accession No. AAB34741); Transferrin receptor [human, K562 erythroleukemia cells, Peptide Partial, 23 aa] [Homo sapiens] (SEQ ID NO: 25) (NCBI Accession No. AAB19499); Transferrin receptor p95, TfR p95 (internal fragment) [human, prostatic-carcinoma cell line DU 145, Peptide Partial, 15 aa, segment 1 of 2] [Homo sapiens] (SEQ ID NO: 26) (NCBI Accession No. AAB34739); and transferrin receptor 2, TFR2 [Homo sapiens] (NCBI Accession No. NP\_003218).

[0150]

B. Nucleotide Sequences Encoding for Transferrin Receptor Related Apoptosis Inducing Proteins (TRRAIPs)

[0151] Non-limiting examples of nucleotide sequences which encode for TRRAIPs include Homo sapiens transferrin receptor (p90, CD71) (TFRC), mRNA [Homo sapiens] (SEQ ID NO. 27) (NCBI Accession No. XM\_052730); Homo sapiens transferrin receptor (TFRC) gene, complete cds [Homo sapiens] (SEQ ID NO. 28) (NCBI Accession No. AF187320); Homo sapiens, transferrin receptor (p90, CD71), clone MGC:3151 IMAGE:3354176, mRNA, complete cds [Homo sapiens] (SEQ ID NO. 29) (NCBI Accession No.

BC001188); Homo sapiens transferrin receptor (p90, CD71) (TFRC), mRNA [Homo sapiens] (SEQ ID NO. 30) (NCBI Accession No. NM\_003234); Human mRNA for transferrin receptor [Homo sapiens] (SEQ ID NO. 31) (NCBI Accession No. X01060); Human transferrin receptor mRNA, complete cds. [Homo Sapiens] (SEQ ID NO. 32) (NCBI Accession No. M11507); Transferrin receptor [guinea pigs, liver, mRNA Partial, 189 nt] [Cavia (guinea pigs)] (SEQ ID NO. 33) (NCBI Accession No. S81327).

C. Clathrin Heavy Chain Related Apoptosis Inducing Proteins (CHCRAIPs)

[0152] Non-limiting examples of CHCRAIPs include Clathrin, heavy polypeptide-like 2 [Homo sapiens] (SEQ ID NO. 34) (NCBI Accession No. NP\_004850); Clathrin, heavy polypeptide-like 1 isoform a [Homo sapiens] (NCBI Accession No. NP\_001826); Clathrin, heavy polypeptide-like 1 isoform b [Homo sapiens] (NCBI Accession No. NP\_009029); Muscle clathrin heavy chain [Homo sapiens] (NCBI Accession No. AAC50494); Clathrin heavy chain 2 [Homo sapiens] (NCBI Accession No. AAB40909); Clathrin heavy chain 2 [Homo sapiens] (NCBI Accession No. AAB40908); KIAA0034 [Homo sapiens] (NCBI Accession No. BAA04801); Clathrin heavy chain polypeptide [Homo sapiens] (NCBI Accession No. CAA64753); Clathrin heavy chain polypeptide [Homo sapiens] (NCBI Accession No. CAA64752); Clathrin heavy chain [Homo sapiens] (NCBI Accession No. CAA39363); Clathrin heavy chain [Rattus norvegicus] (NCBI Accession No. AAA40874); Clathrin, heavy polypeptide (Hc) [Rattus norvegicus] (NCBI Accession No. NP\_062172); Clathrin heavy chain [Bos taurus] (NCBI Accession No. AAC48524); Clathrin, heavy polypeptide (Hc) [Bos taurus] (NCBI Accession No. NP\_776448); Clathrin heavy-chain [Gallus gallus] (NCBI Accession No. CAD20886); Clathrin heavy-chain [Gallus gallus] (NCBI Accession No. CAD22061); Clathrin heavy-chain [Gallus gallus] (NCBI Accession No. CAD22060); Clathrin heavy-chain [Gallus gallus] (NCBI Accession No. CAD22059); Clathrin heavy-chain [Gallus gallus]

(NCBI Accession No. CAD22058); Clathrin heavy-chain [Gallus gallus] (NCBI Accession No. CAD22057); RIKEN cDNA 3110065L21 [Mus musculus] (NCBI Accession No. XP\_126363); RIKEN cDNA 3110065L21 [Mus musculus] (NCBI Accession No. XP\_181312); mKIAA0034 protein [Mus musculus] (NCBI Accession No. BAC65475); Similar to RIKEN cDNA 3110065L21 gene [Mus musculus] (NCBI Accession No. AAH31408); PRO2051 [Homo sapiens] (NCBI Accession No. AAG35490); Clathrin heavy chain 1 (CLH-17) [Homo sapiens] (NCBI Accession No. Q00610); CLATHRIN HEAVY CHAIN [Bos taurus] (NCBI Accession No. P49951); Clathrin heavy chain [Rattus norvegicus] (NCBI Accession No. P11442); Clathrin heavy chain – rat [Rattus norvegicus] (NCBI Accession No. LRRTH); Clathrin heavy chain 2 – human [Homo sapiens] (NCBI Accession No. G02757); Chain B, Clathrin Heavy-Chain Terminal Domain And Linker [Rattus norvegicus] (NCBI Accession No. 1BPO\_B); Chain C, Clathrin Heavy-Chain Terminal Domain And Linker [Rattus norvegicus] (NCBI Accession No. 1BPO\_C); Chain B, Peptide-In-Groove Interactions Link Target Proteins To The B-Propeller Of Clathrin [Rattus norvegicus] (NCBI Accession No. 1C9I\_B); Chain B, Peptide-In-Groove Interactions Link Target Proteins To The B-Propeller Of Clathrin [Rattus norvegicus] (NCBI Accession No. 1C9L\_B); Clathrin heavy chain 2 (CLH-22) [Homo sapiens] (NCBI Accession No. P53675); Clathrin heavy chain – human [Homo sapiens] (NCBI Accession No. T09522); Chain A, Clathrin Heavy-Chain Terminal Domain And Linker [Rattus norvegicus] (NCBI Accession No. 1BPO\_A); Chain A, Clathrin Heavy Chain Proximal Leg Segment (Bovine) [Bos taurus] (NCBI Accession No. 1B89\_A); Chain A, Peptide-In-Groove Interactions Link Target Proteins To The B-Propeller Of Clathrin [Rattus norvegicus] (NCBI Accession No. 1C9I\_A); Chain A, Peptide-In-Groove Interactions Link Target Proteins To The B-Propeller Of Clathrin [Rattus norvegicus] (NCBI Accession No. 1C9L\_A); Clathrin heavy chain - human (fragment) [Homo sapiens] (NCBI Accession No. A40573).

D. Nucleotide Sequences Encoding for Clathrin Heavy Chain Related Apoptosis Inducing Proteins (CHCRAIPs)

**[0153]** Non-limiting examples of nucleotide sequences which encode for CHCRAIPs include Clathrin, heavy polypeptide (Hc) (CLTC) [Homo sapiens] (SEQ ID NO. 35) (NCBI Accession No. NM\_004859); Clathrin, heavy polypeptide-like 1 (CLTCL1), transcript variant 1, [Homo sapiens] (NCBI Accession No. NM\_001835); Clathrin, heavy polypeptide-like 1 (CLTCL1), transcript variant 2 [Homo sapiens] (NCBI Accession No. NM\_007098); Human muscle specific clathrin heavy chain (CLTD), complete cds (NCBI Accession No. U41763); Human clathrin heavy chain 2 (CLTCL) mRNA, complete cds [Homo sapiens] (NCBI Accession No. U60803); Human clathrin heavy chain 2 (CLTCL) mRNA, longer alternatively spliced transcript, complete cds [Homo sapiens] (NCBI Accession No. U60802); Homo sapiens KIAA0034 mRNA, complete cds [Homo sapiens] (NCBI Accession No. D21260); H.sapiens mRNA for clathrin heavy chain [Homo sapiens] (NCBI Accession No. X95487); H.sapiens mRNA for clathrin heavy chain (alternatively spliced) [Homo sapiens] (NCBI Accession No. X95486); Human mRNA for clathrin heavy chain, partial [Homo sapiens] (NCBI Accession No. X55878) Rat clathrin heavy chain mRNA, complete cds [Rattus norvegicus] (NCBI Accession No. J03583); Rattus norvegicus clathrin, heavy polypeptide (Hc) (Cltc), mRNA [Rattus norvegicus] (NCBI Accession No. NM\_019299); Bos taurus clathrin heavy chain mRNA, complete cds [Bos taurus] (NCBI Accession No. U31757); Bos taurus clathrin, heavy polypeptide (Hc) (CLTC), mRNA [Bos taurus] (NCBI Accession No. NM\_174023); Gallus gallus partial mRNA for clathrin heavy-chain (CHC gene) [Gallus gallus] (NCBI Accession No. AJ427965); Gallus gallus partial chc gene for clathrin heavy-chain, exons14-17 [Gallus gallus] (NCBI Accession No. AJ429076); Gallus gallus partial chc gene for clathrin heavy-chain, exons 12-13 [Gallus gallus] (NCBI Accession No. AJ429075); Gallus gallus partial chc gene for clathrin heavy-chain, exon 11 [Gallus gallus] (NCBI Accession No. AJ429074); Gallus gallus partial chc gene for clathrin



heavy-chain, exons 4-10 [Gallus gallus] (NCBI Accession No. AJ429073); Gallus gallus partial chc gene for clathrin heavy-chain, exons 1-3 [Gallus gallus] (NCBI Accession No. AJ429072); Mus musculus clathrin, heavy polypeptide (Hc) (Cltc), mRNA [Mus musculus] (NCBI Accession No. XM\_126363); Mus musculus clathrin, heavy polypeptide (Hc) (Cltc), mRNA [Mus musculus] (NCBI Accession No. XM\_181312); Mus musculus mRNA for mKIAA0034 protein [Mus musculus] (NCBI Accession No. AK122193); Mus musculus, Similar to RIKEN cDNA 3110065L21 gene, clone IMAGE:4949242, mRNA, partial cds. (NCBI Accession No. BC031408); Homo sapiens clone FLB7715 PRO2051 mRNA, complete cds [Homo sapiens] (NCBI Accession No. AF130062).

E. IQ motif containing GTPase Activating Protein Related Apoptosis Inducing Proteins (IQGAPRAIPs)

[0154] Non-limiting examples of IQGAPRAIPs include IQ motif containing GTPase activating protein 1 [Homo sapiens] (SEQ ID NO. 36) (NCBI Accession No. NP\_003861); KIAA0051 [Homo sapiens] (NCBI Accession No. BAA06123); Ras GTPase-activating-like protein [Homo sapiens] (NCBI Accession No. AAA59187); IQ motif containing GTPase activating protein 1 [Mus musculus] (NCBI Accession No. NP\_057930); IQ motif containing GTPase activating protein 1 [Mus musculus] (NCBI Accession No. AAF60344); IQ motif containing GTPase activating protein 1 [Mus musculus] (NCBI Accession No. AAH46385); Similar to IQ motif containing GTPase activating protein 1 [Mus musculus] (NCBI Accession No. AAH37685); Unnamed protein product [Mus musculus] (NCBI Accession No. BAC26538); Unnamed protein product [Mus musculus] (NCBI Accession No. BAC36765); Unnamed protein product [Mus musculus] (NCBI Accession No. BAC26450); Unnamed protein product [Mus musculus] (NCBI Accession No. BAB30486); Unnamed protein product [Mus musculus] (NCBI Accession No. BAC28488); IQGAP1 protein [Homo sapiens] (NCBI Accession No. AAL02166); Similar to chromobox homolog 3 [Rattus norvegicus] (NCBI Accession No.

XP\_218836); Ras GTPase-activating-like protein IQGAP1 (P195) [Homo sapiens] (NCBI Accession No. P46940); Ras GTPase activating protein-related protein – human [Homo sapiens] (NCBI Accession No. A54854); Ras GTPase-activating-like protein IQGAP1 [Mus musculus] (NCBI Accession No. Q9JKF1); Sequence 1 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74847); Sequence 3 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74848); Sequence 22 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74867); Sequence 17 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74862); Sequence 20 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74865); Sequence 18 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74863); Sequence 19 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74864); Sequence 21 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74866); Sequence 13 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74858); Sequence 12 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74857); Sequence 15 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74860); Sequence 14 from patent US 5639651 [Unknown] (NCBI Accession No. AAB74859).

F. Nucleotide Sequences Encoding for IQ motif containing GTPase Activating Protein Related Apoptosis Inducing Proteins (IQGAPRAIPs)

[0155] Non-limiting examples of nucleotide sequences which encode for IQGAPRAIPs include Homo sapiens IQ motif containing GTPase activating protein 1(IQGAP1), mRNA [Homo sapiens] (SEQ ID NO. 37) (NCBI Accession No. NM\_003870); Homo sapiens KIAA0051 mRNA, complete cds [Homo sapiens] (NCBI Accession No. D29640); Homo sapiens ras GTPase-activating-like protein (IQGAP1) mRNA, complete cds [Homo sapiens] (NCBI Accession No. L33075); Mus musculus IQ motif containing GTPase activating protein 1(Iqgap1), mRNA [Mus musculus] (NCBI Accession No. NM\_016721); Mus musculus IQ motif containing GTPase activating protein 1

(Iqgap1) mRNA, complete cds [Mus musculus] (NCBI Accession No. AF240630); Mus musculus, IQ motif containing GTPase activating protein 1, clone MGC:51367 IMAGE:3256630, mRNA, complete cds [Mus musculus] (NCBI Accession No. BC046385); Mus musculus, Similar to IQ motif containing GTPase activating protein 1, clone IMAGE:3673375, mRNA, partial cds [Mus musculus] (NCBI Accession No. BC037685); Mus musculus adult male testis cDNA, RIKEN full-length enriched library, clone:4930417E17 product:IQ motif containing GTPase activating protein 1, full insert sequence [Mus musculus] (NCBI Accession No. AK029631); Mus musculus adult male pituitary gland cDNA, RIKEN full-length enriched library, clone:5330436H04 product:IQ motif containing GTPase activating protein 1, full insert sequence [Mus musculus] (NCBI Accession No. AK077354); Mus musculus 0 day neonate head cDNA, RIKEN full-length enriched library, clone:4833436C10 product:IQ motif containing GTPase activating protein 1, full insert sequence [Mus musculus] (NCBI Accession No. AK029434); Mus musculus adult male testis cDNA, RIKEN full-length enriched library, clone:4933424L13 product:IQ motif containing GTPase activating protein 1, full insert sequence [Mus musculus] (NCBI Accession No. AK016896); Mus musculus adult male epididymis cDNA, RIKEN full-length enriched library, clone:9230116M15 product:IQ motif containing GTPase activating protein 1, full insert sequence (NCBI Accession No. AK033829); Homo sapiens IQGAP1 protein mRNA, partial cds [Homo sapiens] (NCBI Accession No. AF401205); Rattus norvegicus similar to chromobox homolog 3, mRNA [Rattus norvegicus] (NCBI Accession No. XM\_218836).

G. Heat Shock Protein Related Apoptosis Inducing Proteins (HSPRAIPs)

[0156] Non-limiting examples of HSPRAIPs include Heat shock 90kDa protein 1, beta; heat shock 90kD protein 1, beta [Homo sapiens] (SEQ ID NO. 38) (NCBI Accession No. NP\_031381); 90 kD heat shock protein [Homo

sapiens] (NCBI Accession No. AAA36026); Unknown (protein for MGC:10493) [Homo sapiens] (NCBI Accession No. AAH04928); Unknown (protein for MGC:3483) [Homo sapiens] (NCBI Accession No. AAH12807); Unknown (protein for MGC:23206) [Homo sapiens] (NCBI Accession No. AAH14485); Unknown (protein for MGC:1138) [Homo sapiens] (NCBI Accession No. AAH16753); Similar to heat shock protein 84 - mouse [Rattus norvegicus] (NCBI Accession No. XP\_217339); 90kDa heat shock protein [Homo sapiens] (NCBI Accession No. AAA36025); Heat shock protein 90 beta [Equus caballus] (NCBI Accession No. BAB20776); Hypothetical protein [Homo sapiens] (NCBI Accession No. CAB66478); Chaperone protein HSP90 beta [Homo sapiens] (NCBI Accession No. AAF82792); Heat shock 90kD protein 1, beta [Homo sapiens] (NCBI Accession No. AAH09206); Hsp89-alpha-delta-N [Homo sapiens] (NCBI Accession No. AAC25497); Unknown (protein for MGC:30059) [Homo sapiens] (NCBI Accession No. AAH23006); 90 kDa heat-shock protein (AA 1-732) [Homo sapiens] (NCBI Accession No. CAA33259); heat shock 90kDa protein 1, alpha; heat shock 90kD protein 1, alpha [Homo sapiens] (NCBI Accession No. NP\_005339); Heat shock protein [Homo sapiens] (NCBI Accession No. AAA63194); Unknown (protein for IMAGE:3446372) [Homo sapiens] (NCBI Accession No. AAH00987); Similar to heat shock 90kD protein 1, alpha [Homo sapiens] (NCBI Accession No. AAH07989); Similar to heat shock protein 84 [Mus musculus] (NCBI Accession No. AAH44888); Unnamed protein product [Homo sapiens] (NCBI Accession No. BAB15121); Unnamed protein product [Homo sapiens] (NCBI Accession No. CAD62296); Similar to heat shock 90kDa protein 1, alpha; heat shock 90kD protein 1, alpha [Homo sapiens] (NCBI Accession No. XP\_084514); Heat shock protein 90 beta [Bos taurus] (NCBI Accession No. CAC84136); Similar to heat shock protein 84 - mouse [Rattus norvegicus] (NCBI Accession No. XP\_234134); Similar to Heat shock protein HSP 90-beta (HSP 84) (HSP 90) [Homo sapiens] (NCBI Accession No. XP\_055551); Heat shock protein 90 alpha [Coturnix japonica] (NCBI Accession No. AAL83217); Heat shock protein 86 (AA 1 - 312) [Homo sapiens] (NCBI

Accession No. CAA30255); Heat shock protein 86 [Homo sapiens] (NCBI Accession No. AAA36023); Unnamed protein product [Mus musculus] (NCBI Accession No. BAC40681); Similar to heat shock protein 86 [Rattus norvegicus] (NCBI Accession No. XP\_216334); Heat shock protein 86 [Homo sapiens] (NCBI Accession No. AAA36024); Similar to heat shock protein 84 - mouse [Mus musculus] (NCBI Accession No. XP\_138010); ebiP7687 [Anopheles gambiae str. PEST] (NCBI Accession No. EAA04769); Similar to heat-shock protein hsp84 [Rattus norvegicus] ] (NCBI Accession No. XP\_215734); Similar to heat shock protein 84 - mouse [Mus musculus] (NCBI Accession No. XP\_111980); Heat shock protein 90 alpha [Cyprinus carpio] (NCBI Accession No. AAD50972); Stress protein HSP90-beta [Cyprinus carpio] (NCBI Accession No. AAD50973); HSP90; HSP84 [Mus sp.] (NCBI Accession No. AAB23704); Similar to heat-shock protein hsp84 [Rattus norvegicus] (NCBI Accession No. XP\_227737); 90 kDa heat-shock protein [Scyllorhinus torazame] (NCBI Accession No. AAG22091); Similar to heat-shock protein hsp84 [Rattus norvegicus] (NCBI Accession No. XP\_227300); Similar to heat shock protein 86 [Rattus norvegicus] (NCBI Accession No. XP\_218659); Heat shock protein 90 [Homo sapiens] (NCBI Accession No. BAA13431); Similar to Heat shock protein HSP 90-beta (HSP 84) [Rattus norvegicus] ] (NCBI Accession No. XP\_226259); Similar to hypothetical protein DKFZp761K0511.1 - human [Rattus norvegicus] (NCBI Accession No. XP\_236446); Similar to Heat shock protein HSP 90-beta (HSP 84) [Mus musculus] ] (NCBI Accession No. XP\_195404); Unnamed protein product [Homo sapiens] (NCBI Accession No. CAD66568); Heat shock protein 84 [Mus musculus] (NCBI Accession No. AAC36532); Heat shock protein beta [Homo sapiens] (NCBI Accession No. BAA22050); Heat shock protein 90 [Xenopus laevis] (NCBI Accession No. AAA96259); Heat shock protein 90 [Danio rerio] (NCBI Accession No. AAA97519); Similar to heat-shock protein hsp84 [Rattus norvegicus] (NCBI Accession No. XP\_217390); Similar to heat shock protein 86 [Rattus norvegicus] [Homo sapiens] (NCBI Accession No. XP\_060949); Heat shock protein 90 [Danio rerio] (NCBI

Accession No. AAA97518); Heat shock protein 90 [*Meloidogyne arenaria*] (NCBI Accession No. AAO14541); Similar to Heat shock protein HSP 90-beta (HSP 84) [*Homo sapiens*] (NCBI Accession No. XP\_210549); Heat shock protein 90 [*Pratylenchus crenatus*] (NCBI Accession No. AAO14543); hsp-90 [*Meloidogyne incognita*] (NCBI Accession No. AAN76188); Heat shock protein 90 [*Meloidogyne sasserii*] (NCBI Accession No. AAO14542); hsp-90 [*Heterodera* sp. AAMS-2002] (NCBI Accession No. AAN76187); Heat shock protein 90 [*Pratylenchus teres*] (NCBI Accession No. AAO14545); Heat shock protein 90 [*Bursaphelenchus xylophilus*] (NCBI Accession No. AAO14540); Heat shock protein 90 [*Pratylenchus teres*] (NCBI Accession No. AAO14544); Similar to Heat shock protein HSP 90-beta (HSP 84) [*Homo sapiens*] (NCBI Accession No. XP\_210729); 90-kda heat shock protein beta HSP90 beta [*Homo sapiens*] (NCBI Accession No. AAD14062); Heat shock protein hsp-90 [*Heterodera glycines*] (NCBI Accession No. AAN76047); Heat shock protein hsp-90 [*Heterodera glycines*] (NCBI Accession No. AAN76049); Heat shock protein hsp-90 [*Heterodera glycines*] (NCBI Accession No. AAN76045); Heat shock protein hsp-90 [*Heterodera glycines*] (NCBI Accession No. AAN76186); Heat shock protein hsp-90 [*Heterodera glycines*] (NCBI Accession No. AAN76048); Heat shock protein hsp-90 [*Heterodera glycines*] (NCBI Accession No. AAN76185); Heat shock protein hsp-90 [*Heterodera glycines*] (NCBI Accession No. AAN76046); Heat shock protein [*Mus musculus*] (NCBI Accession No. AAA37867); Similar to Heat shock protein HSP 90-beta (HSP 84) (HSP 90) [*Mus musculus*] (NCBI Accession No. XP\_285390); Heat shock protein 90 [*Gallus gallus*] (NCBI Accession No. CAA33132); Similar to Heat shock protein HSP 90-alpha (HSP 86) [*Rattus norvegicus*] (NCBI Accession No. XP\_216245); hsp82 heat shock protein [*Tetrahymena thermophila*] (NCBI Accession No. AAD41356); Heat shock protein 83-2 [*Leishmania infantum*] (NCBI Accession No. CAD30507); Similar to Heat shock protein HSP 90-beta (HSP 84) [*Rattus norvegicus*] (NCBI Accession No. XP\_224384); Heat shock protein HSP 90-beta (HSP 84) (HSP 90) [*Homo sapiens*] (NCBI Accession No. P08238); Heat shock protein

84 – mouse [*Mus musculus* (house mouse)] (NCBI Accession No. HHMS84); Heat shock protein 90-beta [validated] – human [*Homo sapiens*] (NCBI Accession No. HHHU84); Heat shock protein 90kD [*Homo sapiens*] (NCBI Accession No. 1307197A); Heat shock protein HSP 90-beta (HSP 84) [*Equus caballus* (horse)] (NCBI Accession No. Q9GKX8); Hypothetical protein DKFZp761K0511.1 – human [*Homo sapiens*] (NCBI Accession No. T46243); Heat shock protein HSP 90-alpha (HSP 86) [*Homo sapiens*] (NCBI Accession No. P07900); Heat shock protein 90-alpha – human [*Homo sapiens*] (NCBI Accession No. HHHU86); 86K heat shock protein IV - human (fragment) [*Homo sapiens*] (NCBI Accession No. JQ0129); Human Hsp90 Geldanamycin-Binding Domain, 'closed' Conformation [*Homo sapiens*] (NCBI Accession No. 1YER); Human Hsp90 Geldanamycin-Binding Domain, 'open' Conformation [*Homo sapiens*] (NCBI Accession No. 1YES); Geldanamycin Bound To The Hsp90 Geldanamycin-Binding Domain [*Homo sapiens*] (NCBI Accession No. 1YET); Chain A, Hsp90 N-Terminal Domain Bound To Adp-Mg [*Homo sapiens*] (NCBI Accession No. 1BYQ\_A); HSP90 - mouse (fragment) [*Mus sp.*] (NCBI Accession No. I57523); Heat shock protein 90 beta - zebra fish [*Danio rerio*] (NCBI Accession No. JC2344); Heat shock protein 90 alpha - zebra fish [*Danio rerio*] (NCBI Accession No. JC2343); Heat shock protein 90 - bovine (fragments) [*Bos taurus*] (NCBI Accession No. PC2185); Heat shock protein 84 homolog, brain-specific - rat (fragment) [*Rattus norvegicus*] (NCBI Accession No. A61052); Ca<sup>2+</sup>/calmodulin-dependent protein kinase (EC 2.7.1.123) III, eEF-2 specific - rabbit (fragments) [*Oryctolagus cuniculus*] (NCBI Accession No. A41163); hsp 84 homolog {internal fragment} [rats, A1 embryo fibroblast cell line, Peptide Partial, 24 aa, segment 2 of 3] [*Rattus sp.*] (NCBI Accession No. AAB47167); Heat shock protein, 90K - bovine (fragment) [*Bos taurus*] (NCBI Accession No. S13268); Heat shock 90K protein - bovine (fragments) [*Bos taurus*] (NCBI Accession No. A27683); Heat shock protein HSP 90-alpha [*Oryctolagus cuniculus*] (NCBI Accession No. P30946); Heat shock protein 90 - rat (fragment) [*Rattus norvegicus*] (NCBI Accession No. S71306); hsp 84

homolog {internal fragment} [rats, A1 embryo fibroblast cell line, Peptide Partial, 15 aa, segment 1 of 3] [Rattus sp.] (NCBI Accession No. AAB47165).

H. Nucleotide Sequences Encoding for Heat Shock Protein Related Apoptosis Inducing Proteins (HSPRAIPs)

[0157] Non-limiting examples of nucleotide sequences which encode for HSPRAIPs include Homo sapiens heat shock 90kDa protein 1, beta (HSPCB), mRNA [Homo sapiens] (SEQ ID NO. 39) (NCBI Accession No. NM\_007355); Human 90 kD heat shock protein gene, complete cds [Homo sapiens] (NCBI Accession No. J04988); Homo sapiens, clone MGC:10493 IMAGE:3621040, mRNA, complete cds [Homo sapiens] (NCBI Accession No. BC004928); Homo sapiens, clone MGC:3483 IMAGE:3530042, mRNA, complete cds [Homo sapiens] (NCBI Accession No. BC012807); Homo sapiens, clone MGC:23206 IMAGE:4870198, mRNA, complete cds Homo sapiens] (NCBI Accession No. BC014485); Homo sapiens, clone MGC:1138 IMAGE:2987963, mRNA, complete cds [Homo sapiens] (NCBI Accession No. BC016753); Rattus norvegicus similar to heat shock protein 84 – mouse (LOC301252), mRNA [Rattus norvegicus] (NCBI Accession No. XM\_217339); Human 90-kDa heat-shock protein gene, cDNA, complete [Homo sapiens] (NCBI Accession No. M16660); Equus caballus Hsp90beta mRNA for heat shock protein 90 beta, partial cds [Equus caballus] (NCBI Accession No. AB043676); Homo sapiens mRNA; cDNA DKFZp761K0511 (from clone DKFZp761K0511); partial cds [Homo sapiens] (NCBI Accession No. AL136543); Homo sapiens isolate Liv chaperone protein HSP90 beta (HSP90BETA) mRNA, complete cds [Homo sapiens] (NCBI Accession No. AF275719); Homo sapiens, heat shock 90kD protein 1, beta, clone MGC:16067 IMAGE:3615632, mRNA, complete cds. [Homo sapiens] (NCBI Accession No. BC009206); Homo sapiens Hsp89-alpha-delta-N mRNA, complete cds [Homo sapiens] (NCBI Accession No. AF028832); Homo sapiens, clone MGC:30059 IMAGE:4404328, mRNA, complete cds [Homo sapiens] (NCBI Accession No. BC023006); Human mRNA for 90-kDa heat-



shock protein [Homo sapiens] (NCBI Accession No. X15183); Homo sapiens heat shock 90kDa protein 1, alpha (HSPCA), mRNA [Homo sapiens] (NCBI Accession No. NM\_005348); Homo sapiens heat shock protein (HSP89-alpha) gene, complete cds [Homo sapiens] (NCBI Accession No. M27024); Homo sapiens, clone IMAGE:3446372, mRNA, partial cds [Homo sapiens] (NCBI Accession No. BC000987); Homo sapiens, Similar to heat shock 90kD protein 1, alpha, clone IMAGE:3030617, mRNA, partial cds [Homo sapiens] (NCBI Accession No. BC007989); Mus musculus, similar to heat shock protein 84, clone IMAGE:3588159, mRNA, partial cds [Mus musculus] (NCBI Accession No. BC044888); Homo sapiens cDNA: FLJ21717 fis, clone COL10322 [Homo sapiens] (NCBI Accession No. AK025370); Human full-length cDNA clone CS0CAP007YF18 of Thymus of Homo sapiens (human) [Homo sapiens] (NCBI Accession No. BX247955); Homo sapiens heat shock 90kDa protein 1, alpha-like 3 (HSPCAL3), mRNA [Homo sapiens] (NCBI Accession No. XM\_084514); Bos taurus partial mRNA for heat shock protein 90 beta (hsp90 beta gene) [Bos taurus (cow)] (NCBI Accession No. AJ308989); Rattus norvegicus similar to heat shock protein 84 - mouse (LOC314117), mRNA [Rattus norvegicus] (NCBI Accession No. XM\_234134); Homo sapiens similar to Heat shock protein HSP 90-beta (HSP 84) (HSP 90) (LOC220763), mRNA [Homo sapiens] (NCBI Accession No. XM\_055551); Coturnix japonica heat shock protein 90 alpha mRNA, partial cds [Coturnix japonica] (NCBI Accession No. AF473560); Human mRNA for heat shock protein hsp86 [Homo sapiens] (NCBI Accession No. X07270); Human heat shock protein 86 (HSP86) gene, exons 2-6 [Homo sapiens] (NCBI Accession No. M30626); Mus musculus 2 days neonate thymus thymic cells cDNA, RIKEN full-length enriched library, clone:E430034E15 product:heat shock protein, 86 kDa 1, full insert sequence [Mus musculus (house mouse)] (NCBI Accession No. AK088975); Rattus norvegicus similar to heat shock protein 86 [Rattus norvegicus] (LOC297852), mRNA (NCBI Accession No. XM\_216334); Human heat shock protein 86 mRNA, 5'end [Homo sapiens] (NCBI Accession No. M30627); Mus musculus similar to heat shock protein

84 - mouse (LOC207908), mRNA (NCBI Accession No. XM\_138010); *Anopheles gambiae* str. PEST CRA\_x9P1GAV591D, whole genome shotgun sequence [*Anopheles gambiae* str. PEST] (NCBI Accession No. AAAB01008807); *Rattus norvegicus* similar to heat-shock protein hsp84 (LOC295614), mRNA [*Rattus norvegicus*] (NCBI Accession No. XM\_215734); *Mus musculus* similar to heat shock protein 84 - mouse (LOC194839), mRNA [*Mus musculus*] (NCBI Accession No. XM\_111980); *Cyprinus carpio* heat shock protein 90 alpha mRNA, partial cds [*Cyprinus carpio*] (NCBI Accession No. AF170295); *Cyprinus carpio* stress protein HSP90-beta mRNA, partial cds [*Cyprinus carpio*] (NCBI Accession No. AF170296); HSP90=heat shock protein [mice, heart, mRNA Partial, 806 nt] [*Mus sp.*] (NCBI Accession No. S46109); *Rattus norvegicus* similar to heat-shock protein hsp84 (LOC310888), mRNA (NCBI Accession No. XM\_227737); *Scyliorhinus torazame* 90 kDa heat-shock protein (hsp90) mRNA, partial cds [*Scyliorhinus torazame*] (NCBI Accession No. AF306643); *Rattus norvegicus* similar to heat-shock protein hsp84 (LOC310531), mRNA [*Rattus norvegicus*] (NCBI Accession No. XM\_227300); *Rattus norvegicus* similar to heat shock protein 86 [*Rattus norvegicus*] (LOC308623), mRNA ] (NCBI Accession No. XM\_218659); Human heart mRNA for heat shock protein 90, partial cds [*Homo sapiens*] (NCBI Accession No. D87666); *Rattus norvegicus* similar to Heat shock protein HSP 90-beta (HSP 84) (LOC291871), mRNA [*Rattus norvegicus*] (NCBI Accession No. XM\_226259); *Rattus norvegicus* similar to hypothetical protein DKFZp761K0511.1 -human (LOC315845), mRNA [*Rattus norvegicus*] (NCBI Accession No. XM\_236446); *Mus musculus* similar to Heat shock protein HSP 90-beta (HSP 84) (LOC270366), mRNA [*Mus musculus*] (NCBI Accession No. XM\_195404); Human full-length cDNA 5-PRIME end of clone CS0DN005YI08 of Adult brain of *Homo sapiens* (human) [*Homo sapiens*] (NCBI Accession No. BX248761); *Mus musculus* strain BALB/c heat shock protein 84 (hsp84) mRNA, partial cds [*Mus musculus*] (NCBI Accession No. U89426); *Homo sapiens* DNA for heat shock protein beta,

partial cds [Homo sapiens] (NCBI Accession No. D17804); *Xenopus laevis* heat shock protein 90 (Hsp90) gene, partial cds [Xenopus laevis] (NCBI Accession No. U42697); *Danio rerio* heat shock protein 90 (hsp90) gene, partial cds [Danio rerio] (NCBI Accession No. L35587); *Rattus norvegicus* similar to heat-shock protein hsp84 (LOC301375), mRNA [Rattus norvegicus] (NCBI Accession No. XM\_217390); *Homo sapiens* similar to heat shock protein 86 [Rattus norvegicus] (LOC128364), mRNA [Homo sapiens] (NCBI Accession No. XM\_060949); *Danio rerio* heat shock protein 90 (hsp90) gene, partial cds [Danio rerio] (NCBI Accession No. L35586); *Meloidogyne arenaria* heat shock protein 90 gene, partial cds [Meloidogyne arenaria] (NCBI Accession No. AF457580); *Homo sapiens* similar to Heat shock protein HSP 90-beta (HSP 84) (LOC285288), mRNA [Homo sapiens] (NCBI Accession No. XM\_210549); *Pratylenchus crenatus* heat shock protein 90 gene, partial cds [Pratylenchus crenatus] (NCBI Accession No. AF457582); *Meloidogyne incognita* hsp-90 (hsp-90) gene, partial cds [Meloidogyne incognita] (NCBI Accession No. AF459026); *Meloidogyne sasserii* heat shock protein 90 gene, partial cds [Meloidogyne incognita] (NCBI Accession No. AF457581); *Heterodera* sp. AAMS-2002 hsp-90 (hsp-90) gene, partial cds [Heterodera sp. AAMS-2002] (NCBI Accession No. AF459025); *Pratylenchus teres* isolate RTB heat shock protein 90 gene, partial cds [Pratylenchus teres] (NCBI Accession No. AF457584); *Bursaphelenchus xylophilus* heat shock protein 90 gene, partial cds [Bursaphelenchus xylophilus] (NCBI Accession No. AF457579); *Pratylenchus teres* isolate JK heat shock protein 90 gene, partial cds [Pratylenchus teres] (NCBI Accession No. AF457583); *Homo sapiens* similar to Heat shock protein HSP 90-beta (HSP 84) (LOC286192), mRNA [Homo sapiens] (NCBI Accession No. XM\_210729); D6S182=90-kda heat shock protein beta HSP90 beta [human, Genomic,346 nt, segment 2 of 2] [Homo sapiens] (NCBI Accession No. S70561); *Heterodera glycines* strain TN5 heat shock protein hsp-90 (hsp90) gene, partial cds [Heterodera glycines] (NCBI Accession No. AF449487); *Heterodera glycines* strain TN8 heat shock protein hsp-90 (hsp90) gene, partial cds [Heterodera glycines] (NCBI

Accession No. AF449489): *Heterodera glycines* strain OP50 heat shock protein hsp-90 (hsp90) gene, partial cds [*Heterodera glycines*] (NCBI Accession No. AF449485); *Heterodera glycines* strain TN7 heat shock protein hsp-90 gene, partial cds [*Heterodera glycines*] (NCBI Accession No. AF457464); *Heterodera glycines* strain TN6 heat shock protein hsp-90 (hsp90) gene, partial cds [*Heterodera glycines*] (NCBI Accession No. AF449488); *Heterodera glycines* strain OP25 heat shock protein hsp-90 gene, partial cds [*Heterodera glycines*] (NCBI Accession No. AF457463); *Heterodera glycines* strain NL1-RHp heat shock protein hsp-90 (hsp90) gene, partial cds [*Heterodera glycines*] (NCBI Accession No. AF449486); Mouse heat shock protein (Hsp86) gene, partial cds [*Mus musculus*] (NCBI Accession No. M57673); *Mus musculus* similar to Heat shock protein HSP 90-beta (HSP 84) (HSP 90) (LOC329532), mRNA [*Mus musculus*] (NCBI Accession No. XM\_285390); Chicken hsp90 gene for 90 kDa-heat shock protein 5'-end [*Gallus gallus*] (NCBI Accession No. X15028); *Rattus norvegicus* similar to Heat shock protein HSP 90-alpha (HSP 86) (LOC297539), mRNA [*Rattus norvegicus*] (NCBI Accession No. XM\_216245); *Tetrahymena thermophila* strain CU428.1 hsp82 heat shock protein (HSP82) mRNA, partial cds [*Tetrahymena thermophila*] (NCBI Accession No. AF151113); *Leishmania infantum* hsp83-1 gene for heat shock protein 83-1 and hsp83-2 gene for heat shock protein 83-2 [*Leishmania infantum*] (NCBI Accession No. X87770); *Rattus norvegicus* similar to Heat shock protein HSP 90-beta (HSP 84) (LOC290386), mRNA [*Rattus norvegicus*] (NCBI Accession No. XM\_224384).

[0158] The skilled artisan recognizes the presence of human and statistical error in sequencing nucleotides. Nucleotide sequences determined by automation are typically at least about 90% identical, more typically at least about 95% to at least about 99.9% identical to the actual nucleotide sequence of the sequenced nucleotide molecule. The actual sequence can be more precisely determined by other approaches including manual nucleotide sequencing methods well known in the art. As is also known in the art, a

single insertion or deletion in a determined nucleotide sequence compared to the actual sequence will cause a frame shift in translation of the nucleotide sequence such that the predicted amino acid sequence encoded by a determined nucleotide sequence will be completely different from the amino acid sequence actually encoded by the sequenced DNA molecule, beginning at the point of such an insertion or deletion.

[0159] The skilled artisan also recognizes that nucleotides encoding AIPs may include splice variants of the nucleotides described herein. See, for example Evans, P. and Kemp, J., "Exon/intron structure of the human transferrin receptor gene," *Gene*, 199: 123-31 (1997).

#### IV. Expression Vectors and Transfected Cells

[0160] The present invention also relates to vectors which include the isolated nucleotide molecules of the present invention, host cells which are genetically engineered with the recombinant vectors, and the production of AIP by recombinant techniques. AIP may be extracted from cultures of the below described transfected cells and used for the homogenous and heterogenous assays described herein. Alternatively, AIP can be synthesized for these assays using peptide synthetic techniques known in the art. Also, the below described expression vectors and transfected cells are useful for whole cell assays described herein.

[0161] The polynucleotides may be joined to a vector containing a selectable marker for propagation in a host. Generally, a plasmid vector is introduced in a precipitate, such as a calcium phosphate precipitate, or in a complex with a charged cationic lipid. If the vector is a virus, it may be packaged in vitro using an appropriate packaging cell line and then transduced into host cells.

[0162] The DNA insert should be operatively linked to an appropriate promoter, such as the phage lambda PL promoter, the *E. coli* lac, trp and tac promoters, the SV40 early and late promoters and promoters of retroviral LTRs, to name a few. Other suitable promoters will be known to the skilled

artisan. The expression constructs will further contain sites for transcription initiation, termination and, in the transcribed region, a ribosome binding site for translation. The coding portion of the transcripts expressed by the constructs may include a translation initiating at the beginning and a termination codon (UAA, UGA or UAG) appropriately positioned at the end of the polypeptide to be translated.

[0163] As indicated, the expression vectors may include at least one selectable marker. Such markers include dihydrofolate reductase or neomycin resistance for eukaryotic cell culture and tetracycline or ampicillin resistance genes for culturing in *E. coli* and other bacteria. Representative examples of appropriate hosts include, but are not limited to, bacterial cells, such as *E. coli*, *Streptomyces* and *Salmonella typhimurium* cells; fungal cells, such as yeast cells; insect cells such as *Drosophila* S2 and *Spodoptera Sf9* cells; animal cells such as CHO, COS and Bowes melanoma cells; and plant cells. Appropriate culture mediums and conditions for the above-described host cells are known in the art.

[0164] Vectors which may be used in bacteria include pQE70, pQE60 and pQE-9, available from Qiagen; pBS vectors, Phagescript vectors, Bluescript vectors, pNH8A, pNH 16a, pNH 18A, pNH46A, available from Stratagene; and ptrc99a, pKK223-3, pKK233-3, pDR540, pRIT5 available from Pharmacia. Eukaryotic vectors include pWLNEO, pSV2CAT, pOG44, pXT1 and pSG available from Stratagene; and pSVK3, pBPV, pMSG and pSVL available from Pharmacia. Other suitable vectors will be readily apparent to the skilled artisan.

[0165] Introduction of nucleotides into the host cell can be affected by calcium phosphate transfection, DEAE-dextran mediated transfection, cationic lipid-mediated transfection, electroporation, transduction, infection or other methods. Such methods are described in many standard laboratory manuals, such as Davis et al., *Basic Methods In Molecular Biology* (1986). Methods of formulating nucleotides with compositions (e.g., lipids) to facilitate introduction of the nucleotide into the cell are disclosed in, for example, U.S.

Pat. Nos. 4,897,355, 4,394,448, 4,235,871, 4,231,877, 4,224,179, 4,753,788, 4,673,567, 4,247,411, 4,814,270, 5,279,833, and 5,753,613; and in published U.S. Patent Application 2002/0086849. Other methods for transfecting cells which are useful for the present invention include those described in U.S. Patent Nos. 5,547,932; 5,981,273; 6,022,735; 6,077,663; 6,274,322; and Published International Application No. WO 00/43494.

**[0166]** The polypeptide may be expressed in a modified form, such as a fusion protein, and may include not only secretion signals, but also additional heterologous functional regions. For instance, a region of additional amino acids, particularly charged amino acids, may be added to the N-terminus of the polypeptide to improve stability and persistence in the host cell, during purification, or during subsequent handling and storage. Also, peptide moieties may be added to the polypeptide to facilitate purification. Such regions may be removed prior to final preparation of the polypeptide. The addition of peptide moieties to polypeptides to engender secretion or excretion, to improve stability and to facilitate purification, among others, are familiar and routine techniques in the art. An example of a fusion protein comprises a heterologous region from immunoglobulin that is useful to solubilize proteins. For example, EP-A-O 464 533 (Canadian counterpart 2045869) discloses fusion proteins comprising various portions of constant region of immunoglobulin molecules together with another human protein or part thereof.

**[0167]** AIPs can be recovered and purified from recombinant cell cultures by well-known methods including ammonium sulfate or ethanol precipitation, acid extraction, anion or cation exchange chromatography, phosphocellulose chromatography, hydrophobic interaction chromatography, affinity chromatography, or hydroxylapatite chromatography. High performance liquid chromatography ("HPLC") can also be employed for purification. Polypeptides of the present invention include naturally purified products, products of chemical synthetic procedures, and products produced by recombinant techniques from a prokaryotic or eukaryotic host, including, for example, bacterial, yeast, higher plant, insect and mammalian cells.

Depending upon the host employed in a recombinant production procedure, the polypeptides of the present invention may be glycosylated or may be non-glycosylated. In addition, polypeptides of the invention may also include an initial modified methionine residue, in some cases as a result of host-mediated processes.

#### V. Homogenous and Heterogenous Screening Assays

[0168] One aspect of the present invention relates to a method of identifying AIP binding compounds using homogenous or heterogenous binding assays. This may be accomplished by using non-competitive binding assays, or assays in which test compounds compete with gambogic acid or GA-related compounds such as those described in U.S. Patent No. 6,462,041, or the compounds described in this application, such as the GA-biotin conjugates in Example 1-6, GA-fluorescein conjugates in Example 7-11, GA-agarose in Example 12-13, and radioactive labeled GA analog in Example 14. Any method known to one of ordinary skill in the art that detects binding between a test compound and a protein or antibody may be used in the present invention. These assays may be radioassays, fluorescence polarization assays or other fluorescence techniques, or biotin-avidin based assays. Test compounds capable of binding to AIPs are candidates for activators of apoptosis. Test compounds may be capable of binding to AIPs as strongly or more strongly than gambogic acid or GA-related compounds.

[0169] Another aspect of the present invention relates to a method of identifying AIP binding compounds using antibodies to GA or GA-related compounds. Such a method relates to detecting binding between i) an antibody to gambogic acid or GA-related compounds and ii) a test compound. Because gambogic acid or GA-related compounds bind AIPs, an antibody which is specific for gambogic acid or GA-related compounds is likely to be specific for other compositions having the physical characteristics that afford AIP specific binding. Hence, antibodies can be used to screen chemical



libraries for other compositions that bind AIPs and that activate apoptosis. In such assays, the antibody may give rise to a detectable signal upon binding a test compound. For example, the antibodies may be labeled with a fluorophore. Antibodies bound to a test compound may also be detected using radiolabels.

[0170] Assays for use in the present invention are preferably high throughput screening methods, capable of screening large numbers of compounds in a rapid fashion. This includes, for example, screening methods that use microbeads or plates having multiple wells.

A. Competitive and Non-Competitive Homogenous Binding Assays

[0171] Any homogeneous assay well known in the art can be used in the present invention to determine binding between test compounds of interest and an AIP. For example, radioassays, fluorescence polarization assays and time-resolved fluorescence assays may all be used. Where the AIP is labeled, the assay may be a non-competitive binding assay in which the ability of test compounds to bind the AIP is determined. Where GA or GA-related compounds are labeled, such as those described in Example 1-14 of this application, the assay may be a competitive binding assay where the ability of a test compound to displace the AIP-bound GA or GA-related compound is determined.

[0172] A homogeneous binding assay used in the present invention, and which uses fluorescence to detect the test compound/AIP binding, may employ fluorescently labeled gambogic acid or GA-related compounds, or fluorescently labeled AIP. Any method known to one of ordinary skill in the art can be used to link the fluorophore to gambogic acid, GA-related compound or polypeptide of interest. See, e.g., Richard P. Haugland, *Molecular Probes: Handbook of Fluorescent Probes and Research Chemicals* 1992-1994 (5th edit, 1994, Molecular Probes, Inc.).

[0173] Fluorescence Polarization (FP), first described by Perrin, *J. Phys. Rad.* 1:390-401 (1926), is based upon the finding that the emission of light by a fluorophore can be depolarized by a number of factors, the most predominant being rotational diffusion, or, in other words, the rate at which a molecule tumbles in solution. "Polarization" is the measurement of the average angular displacement of the fluorophore that occurs between the absorption and subsequent emission of a photon. This angular displacement of the fluorophore is, in turn, dependent upon the rate and extent of rotational diffusion during the lifetime of the excited state, which is influenced by the viscosity of the solution and the size and shape of the diffusing fluorescent species. If viscosity and temperature are held constant, the polarization is directly related to the molecular volume or size of the fluorophore. In addition, the polarization value is a dimensionless number (being a ratio of vertical and horizontal fluorescent intensities) and is not affected by the intensity of the fluorophore.

[0174] In fluorescent assays, light from a monochromatic source passes through a vertical polarizing filter to excite fluorescent molecules in a sample tube. Only those molecules that are orientated in the vertically polarized plane absorb light, become excited, and subsequently emit light. The emission light intensity is measured both parallel and perpendicular to the exciting light. The fraction of the original incident, vertical light intensity that is emitted in the horizontal plane is a measure of the amount of rotation that the fluorescently labeled AIP has undergone during the excited state, and therefore is a measure of its relative size. See, "Introduction to Fluorescence Polarization," Pan Vera Corp., Madison, WI, June 17, 1996. Other publications describing the fluorescence polarization technique include G. Weber, *Adv. Protein Chem.* 8:415-459 (1953); W. B. Dandilker, *et al.*, *Immunochemistry* 10:219-227 (1973); and M. E. Jolley, *J. Anal. Toxicol.* 5:236-240 (1981); "Chapter 4 – Introduction to Fluorescence Polarization," the FPM-1<sup>TM</sup> Operators Manual, pp. 9-10, Jolley Consulting and Research, Inc. Grayslake, IL; Lynch, B. A., *et al.*, *Anal. Biochem.* 247:77-82 (1997); Wei, A. P. and Herron, J. N., *Anal.*

*Chem.* 65:3372-3377 (1993); and Kauvar, L. M, *et al.*, *Chem. Biol.* 2:107-118 (1995).

[0175] The apparatus used in fluorescence polarization techniques are well known in the art. Examples of an apparatus used in fluorescence polarization are given in U.S. Patent No. 6,482,601 B1; U.S. Patent No. 6,455,861; U.S. Patent No. 5,943,129; U.S. Patent No. 4,699,512 and U.S. Patent No. 4,548,499. Other specific examples of instruments for use in the invention include, but are limited to, the Sentry-FP<sup>®</sup> fluorescence polarization instrument (Diachemix Corp., Milwaukee, WI); the BEACON<sup>®</sup> 2000 fluorescence polarization instrument (PanVera, Madison, WI); the POLARSCAN<sup>®</sup> portable fluorescence polarization system (Associates of Cape Cod, Inc., Falmouth, MA); the VICTOR<sup>®</sup> series instruments (PerkinElmer, Inc., Wellesley, MA); and the AFFINTY<sup>®</sup> and SYMMETRY<sup>®</sup> fluorescence systems (CRi, Inc., Woborn, MA).

[0176] One embodiment of the invention relates to a non-competitive fluorescent assay. Such an assay employs an AIP covalently attached to a fluorophore. Free AIP has higher fluorescence intensity than AIP bound to a test compound. *Confer* Hwang, *et al.*, *Biochemistry* 31:11536-11545 (1992). Once the test compound/AIP complex is formed, it rotates and tumbles more slowly and has less fluorescence intensity. *Confer* "Introduction to Fluorescence Polarization," Pan Vera Corp., Madison, WI, June 17, 1996; Perrin, *J. Phys. Rad.* 1:390-401 (1926). Hence, when the test compound and an AIP bind, the fluorescence intensity of the labeled AIP decreases proportional to binding.

[0177] In this embodiment, a solution of the labeled AIP is prepared and its fluorescence polarization is measured. The AIP and the test compound are mixed together and the solution is allowed to reach equilibrium over some time period. The fluorescence of any test compound/AIP complex which forms is then measured. The decrease in fluorescence intensity is proportional to binding. The test compound binding may be compared to a baseline fluorescence intensity value determined for gambogic acid or GA-related

compounds bound to AIP. Test compounds that bind to AIP are considered candidates for activators of apoptosis. The skilled artisan will recognize that a variety of parameters such as temperature, time, concentration and pH can be varied to study the binding between the test compound and an AIP.

[0178] The baseline fluorescence polarization value is determined by preparing labeled AIP and measuring its fluorescence polarization. Gambogic acid or a GA-related compound is mixed with labeled AIP and allowed to equilibrate for a sufficient time to form a complex between gambogic acid (or a GA-related compound) and AIP. The fluorescence polarization of the solution comprising the complex is measured. The relative change in the fluorescence polarization is the baseline value against which all other test compounds will be measured. A variety of parameters such as temperature, time, concentration and pH can be varied to develop a range of values for the change in fluorescence polarization under a variety of conditions.

[0179] In determining whether a test compound binds to an AIP strongly enough to be considered a candidate for inducing apoptosis, the change in fluorescence polarization between unbound and bound test compound is compared with the change in fluorescence polarization between unbound and bound gambogic acid or GA-related compounds. Test compounds that bind as strongly as or more strongly than gambogic acid or GA-related compounds are candidates for activators of apoptosis.

[0180] Competitive homogenous fluorescence assays can also be used in the present invention to find new candidates for activating apoptosis. Competitive assays are well known in the art and any method can be used in the present invention. For example, U.S. Patent No. 6,511,815 B1 describes an assay for quantitating competitive binding of test compounds to proteins utilizing fluorescence polarization.

[0181] In this embodiment of the invention, gambogic acid or a GA-related compound is first labeled with a fluorophore. The labeled gambogic acid or GA-related compound is mixed with an AIP in a buffered solution. The mixture is allowed to equilibrate and the fluorescence polarization of the

gambogic acid/AIP (or GA-related compound/AIP) complex is measured. The test compound is then introduced into the mixture and allowed to equilibrate. Where a given test compound effectively competes for an AIP binding site, the labeled gambogic acid (or labeled GA-related compound) will be displaced and become free, labeled gambogic acid (or free, labeled GA-related compound). Because the fluorophore (covalently attached to the GA or GA-related compound) is no longer associated with the bulky AIP, it gives rise to a more intense fluorescence polarization signal. Accordingly, in this embodiment, increases in fluorescent signals are proportional to the ability of a test compound to bind AIP.

[0182] In the above assays, several components of the mixture can affect the fluorescence intensity other than the labeled moiety. The polarity of the solvent and non-specific binding molecules can have significant effects on the intensity, which can be incorrectly interpreted. Therefore, an alternative assay for determining test compound/AIP binding for use in the present invention relies on time-resolved fluorescence techniques, which minimizes the above problems. The method of time-resolved fluorescence is described in detail in I. Hemmilä, *et al.*, "High Throughput Screening. The Discovery of Bioactive Substances," Chapter 20, J. P. Devlin, ed., Marcel Dekker, Inc., New York (1997). The excited state lifetime of the test compound/AIP complex is longer than that for the impurities and other components that add background fluorescence. Therefore, the solution comprising the test compound/AIP complex mixture may be illuminated and after a short period of time on the order of nano to micro seconds, the solution fluorescence is measured.

[0183] In one embodiment of a time-resolved competitive fluorescence based homogeneous assay for use in the present invention, the fluorescent signal is generated when an AIP and GA (or GA-related compound) bind. In this embodiment, either the AIP or GA (or GA-related compound) is covalently bound to an energy donating Eu-cryptate having a long-lived fluorescent excited state. The other is attached to an energy-accepting protein, allophycocyanin, having a short fluorescent excited state. Energy transfer

occurs between the Eu-cryptate and the allophycocyanin when they are less than 7 nm apart. During the assay, the Eu-cryptate is excited by a pulsed laser, and its fluorescent emission continually re-excites the allophycocyanin, whose fluorescence is measured by a time resolved fluorescence reader. *Confer* A. J. Kolb, *et al.*, "High Throughput Screening. The Discovery of Bioactive Substances," Chapter 19, J. P. Devlin, ed., Marcel Dekker, Inc., New York (1997).

[0184] In this embodiment of a time-resolved competitive fluorescence based homogeneous assay, the AIP and GA (or GA-related compound) attached to the Eu-cryptate or allophycocyanin are mixed together and allowed to equilibrate. Once equilibrated, the fluorescence intensity is measured. The test compound is then introduced into the mixture and allowed to equilibrate. Where a given test compound effectively competes for an AIP binding site, the labeled gambogic acid (or labeled GA-related compound) will be displaced and the Eu-cryptate and allophycocyanin will no longer be less than 7 nm apart. Accordingly, the fluorescence intensity will decrease. Hence, in this embodiment, decreases in fluorescent signals is proportional to the ability of a test compound to bind an AIP.

[0185] Alternative homogeneous assays for use in the invention include those described in U.S. Patent No. 6,492,128 B1; U.S. Patent No. 6,406,913 B1; U.S. Patent No. 6,326,459 B1; U.S. Patent No. 5,928,862; U.S. Patent No. 5,876,946; U.S. Patent No. 5,612,221; and U.S. Patent No. 5,556,758.

[0186] The skilled artisan will recognize that radiolabels can also be used in homogenous competitive binding assays. In such assays, GA (or GA-related compound) is radiolabeled and allowed to equilibrate with an AIP in solution. Then, a test compound is introduced into the solution and allowed to equilibrate. The AIP (bound either to radiolabeled GA (or GA-related compound) or to the test compound) is then separated from unbound GA (or GA-related compound) and unbound test compound. Where a test compound is a poor AIP binder, most of the AIP will be bound to radiolabeled GA (or GA-related compound) and this can be detected by a scintillation counter,

photoradiography, or other techniques well known in the art. If, however, the test compound is a strong AIP binder and displaces radiolabeled GA (or GA-related compound), then most of the AIP will not be bound to radiolabeled GA (or GA-related compound). Hence, ability of a test compound to bind an AIP is inversely proportional to the amount of radiolabel detected with the AIP.

#### B. Competitive Heterogenous Binding Assays

[0187] Detection of the test compound binding to AIP may also be accomplished using heterogeneous assays. Heterogeneous assays for use in the present invention may be based on radioassays, fluorescence-based assays and biotin-avidin based assays. In heterogenous assays, a first component is attached to a solid phase such as a bead or other solid substrate and one or more additional components are in solution. For example, an AIP may be bound to a bead or other solid substrate and labeled GA (or GA-related compound) is introduced as a solution. The label may be a radiolabel, chemiluminescent label, fluorescent label, chromogenic label, or other label well known in the art. After the mixture equilibrates and the GA/AIP complexes (or GA-related compound/AIP complexes) form, a solution of test compound is introduced and allowed to equilibrate to form test compound/AIP complexes. The beads or solid components are separated from the solutions. This can be done, for example, using magnetic fields where the beads are magnetic. Alternatively, where an AIP is bound to a solid substrate, separation can occur simply by rinsing the solid substrate with water or a buffer to remove any solution containing unbound labeled GA (or labeled GA-related compound) or unbound test compound. The extent to which an AIP remains associated with the detectably labeled GA (or labeled GA-related compound) is measured. Such measurements can be performed while the AIP remains bound to the bead or solid substrate. Alternatively, such measurements can be made after the AIP has been removed from the bead or

solid substrate. In such competitive binding assays, decreases in signal associated with the detectable label are proportionally related to increases in the ability of test compounds to bind the AIP by displacing GA (or GA-related compounds).

[0188] The skilled artisan recognizes that the GA or GA-related compound may also be the component bound to the beads or solid substrate. In such assays, labeled AIP is introduced as a solution and allowed to equilibrate forming the GA/AIP complexes (or GA-related compound/AIP complexes). The label may be a radiolabel, chemiluminescent label, fluorescent label, chromogenic label, or other label well known in the art. Then, a test compound is added as a solution. If a test compound displaces GA (or a GA-related compound), then the AIP will fall back into solution and not be bound to the bead or solid substrate through GA (or the GA-related compound). As described above, the beads or solid substrate are removed from the solution but the solution is retained to measure the extent of the detectable label. Here, increases in signal associated with the detectable label are proportional to the ability of a test compound to bind AIP.

[0189] Solid phase supports for use in the present invention include any insoluble support known in the art that is capable of binding an AIP or gambogic acid or GA-related compounds. This includes, for example, glass and natural and synthetic polymers such as agaroses, polystyrene, polypropylene, polyethylene, dextran, nylon, amylases, natural and modified celluloses, polyacrylamides, and magnetite. The support material may have virtually any possible structural configuration so long as the support-bound molecule is capable of binding to a test compound, GA (or GA-related compound) or to the AIP. Thus, the support configuration may be spherical, as in a bead, or cylindrical, as in the inside surface of a test tube, or the external surface of a rod, or hemishperical surface such as the well of a microtitre plate. Alternatively, the surface may be flat such as a sheet, test strip, etc. Those skilled in the art will note many other suitable carriers for binding gambogic



acid (or GA-related compounds) or the AIP, or will be able to ascertain the same by use of routine experimentation.

[0190] An example of a heterogeneous assay for use in the present invention is the radioassay. A good description of a radioassay may be found in Laboratory Techniques and Biochemistry in Molecular Biology, by Work, T. S., et al., North Holland Publishing Company, NY (1978), with particular reference to the chapter entitled "An Introduction to Radioimmune Assay and Related Techniques" by Chard, T. Examples of other competitive radioassays are given in U.S. Patent Nos. 3,937,799; 4,102,455; 4,333,918 and 6,071,705. Inherent in such assays is the need to separate the bead or substrate bound component from the solution component. Various ways of accomplishing the required separation have been developed, including those exemplified in U.S. Pat. Nos. 3,505,019; 3,555,143; 3,646,346; 3,720,760; and 3,793,445. The skilled artisan will recognize that separation can include filtering, centrifuging, washing, or draining the solid substrate to insure efficient separation of the substrate bound and solution phases.

[0191] The radioactive isotope or radiolabel can be detected by such means as the use of a gamma counter or a scintillation counter or by audioradiography. Isotopes which are particularly useful for the purpose of the present invention are:  $^3\text{H}$ ,  $^{123}\text{I}$ ,  $^{125}\text{I}$ ,  $^{131}\text{I}$ ,  $^{35}\text{S}$ ,  $^{31}\text{P}$ ,  $^{14}\text{C}$ ,  $^{111}\text{In}$ ,  $^{97}\text{Ru}$ ,  $^{67}\text{Cu}$ ,  $^{67}\text{Ga}$ ,  $^{68}\text{Ga}$ ,  $^{72}\text{As}$ ,  $^{89}\text{Zr}$  and  $^{201}\text{Tl}$ . Those of ordinary skill in the art will know of other suitable labels, which may be employed in accordance with the present invention. The binding of these labeled AIP, GA or GA-related compounds can be accomplished using standard techniques commonly known to those of ordinary skill in the art. Typical techniques are described by Kennedy, J. H., et al. (Clin. Chim. Acta 70:1-31 (1976)), and Schurs, A. H. W. M., et al. (Clin. Chim. Acta 81:1-40 (1977)). In a particular embodiment, one or more hydrogen and/or carbon atoms of the AIP, gambogic acid or GA-related compounds are replaced by  $^3\text{H}$  and  $^{14}\text{C}$ , by methods well known in the art.

[0192] In one embodiment of the invention, the AIP is attached to a solid support. Radiolabeled gambogic acid or a GA-related compound is prepared.

The bound AIP is admixed with the solution comprising radiolabeled gambogic acid or GA-related compound. The mixture is allowed to equilibrate for a time period. A test compound is added to the mixture and allowed to equilibrate for some time period. The test compound competes for the binding site of the AIP with the radiolabeled gambogic acid (or radiolabeled GA-related compound). The solid support that has bound AIP is removed from the mixture. The amount of radiolabel associated with the AIP is measured. Decreases in the amount of radiolabel are proportional to the ability of a test compound to displace GA (or the GA-related compound) and bind the AIP. Alternatively, the radiation of the solution comprising unbound and uncomplexed radiolabeled gambogic acid (or GA-related compound) can be measured. Using this assay, test compounds that bind to the AIP receptor as strongly or more strongly than gambogic acid or GA-related compounds can easily be discovered.

[0193] Alternative labels for use in the heterogeneous assays of the present invention include chemiluminescent labels, such as those described in U.S. Patent No. 4,380,580; and enzyme substrate labels, such as those assays described in U.S. Patent No. 4,492,751. For example, a fluorescent label may be used.

[0194] In these competitive fluorescence-based heterogeneous assays, a solution of fluorescently labeled gambogic acid or a GA-related compound is prepared. An AIP is attached to a solid support. The bound AIP is admixed with the solution comprising fluorescently labeled gambogic acid (or a fluorescently labeled GA-related compound). The mixture is allowed to equilibrate for a time period. A test compound is added to the mixture and the mixture is allowed to equilibrate for some time period. The test compound competes for the binding receptor of the AIP with fluorescently labeled gambogic acid (or a fluorescently labeled GA-related compound). The solid support that has bound the AIP is removed from the mixture. The amount of fluorescence associated with the AIP attributed to the fluorescent label is measured. Decreases in the amount of this fluorescence are proportional to

the ability of a test compound to displace GA (or the GA-related compound) and bind the AIP. Alternatively, the fluorescence of the solution comprising unbound and uncomplexed fluorescently labeled gambogic acid (or GA-related compound) can be measured. Using this assay, test compounds that bind to AIP receptors as strongly or more strongly than gambogic acid or GA-related compounds can easily be discovered.

[0195] An alternative heterogeneous assay for use in the present invention is a biotin/avidin based assay. For examples of the various ways in which this assay can be performed in the present invention, see, *e.g.*, Blake, R. C., *et al. Anal. Biochem.* 272:123-134 (1999); Cho, H. C., *et al. Anal. Sciences* 15:343-347 (1999); Choi, M. H., *et al. Bull. Korean Chem. Soc.* 22:417-420 (2001); U.S. Patent No. 6,096,508; U.S. Patent No. 4,863,876; and U.S. Patent No. 4,228,237. In the present invention, avidin may be labeled with any label, preferably, avidin is fluorescently labeled or conjugated to an enzyme. Any detectably labeled enzyme can be used in the present invention. specific examples include, but are not limited to, horseradish peroxidase, alkaline phosphatase,  $\beta$ -galactosidase and glucose oxidase.

[0196] One particular embodiment of the invention employs a competitive heterogeneous biotin-avidin assay. In this assay, the test compound competes with gambogic acid (or a GA-related compound) for the AIP binding sites. Here, biotinylated gambogic acid (or GA-related compound) is prepared. An AIP bound to solid support is admixed with the biotinylated gambogic acid (or GA-related compound) and incubated for some defined period of time. Gambogic acid or GA-related compound binds to AIP and forms a complex on the solid support. The solid support comprising biotinylated gambogic acid/AIP complexes (or GA-related compound/AIP complexes) is then admixed with a solution comprising the test compound. The mixture is allowed to incubate for some defined period of time. The test compound competes for AIP binding sites. The solid phase is then separated from any solutions containing unbound biotinylated GA (or biotinylated GA-related compound) or unbound test compound, and washed. The solid phase is then

admixed with a composition comprising labeled avidin. The avidin binds only to the biotinylated gambogic acid (or biotinylated GA-related compound). The mixture is allowed to incubate for some defined period of time, and the amount of biotin-avidin complex is measured. The decrease in amount of biotin-avidin complex is directly related to the increase in test compound binding. Test compounds that bind AIPs are candidates as apoptosis inducers.

[0197] The skilled artisan recognizes that in all of the heterogenous competitive assays described above, the ability of a test compound to effectively compete with GA (or GA-related compound) to bind to the AIP can be ascertained by using base line values. For example, a given assay may be done with labeled GA (or GA-related compound). The amount of signal associated with that label found in the labeled GA (or GA-related compound) bound AIP component can be determined to give a base line value. Then, the test compound may be introduced and a second measurement of the signal attributable to the detectable label is taken which can be compared to the base line value. The extent to which the test compound decreases the base line value is a function of the ability of the test compound to bind AIP.

#### C. Assays Using Gambogic Acid or GA-Related Compound Specific Antibodies

[0198] In another aspect of the invention, new candidate drugs that induce apoptosis may be identified by assaying for binding between test compounds of interest and antibodies raised against gambogic acid or a GA-related compound.

[0199] Antibodies to gambogic acid and GA-related compounds may be generated and purified using conventional, well-known methods. Such methods are described for example, in Cohler & Milstein, *Nature*, 256, pp. 495-497 (1975); "Antibodies-A Laboratory Manual", E. Harlow & D. Lane, Coldspring Harbor Laboratory, pp. 55-144 (1988); C. Williams & M. Chase, in "Methods in Immunology & Immunochemistry," Academic Press, New York, Vol. 1, Chap. 3, (1967); and S. Burchiel, in "Methods in Enzymology,"

Vol. 121, Chap. 57, pp. 596-615, Academic Press, New York (1986). In general, an immunogen comprising gambogic acid or a GA-related compound is administered to an animal in order to elicit an immune response against the immunogen. Polyclonal antibodies generated against the immunogen are obtained from the animal antisera and are then purified using well-known methods. Monoclonal antibodies against the immunogen can be obtained from hybridoma cells using well-known methods.

**[0200]** Suitable immunogens for raising polyclonal antibodies include, but are not limited to, bioconjugates of gambogic acid and GA-related compounds. Examples of bioconjugates include, but are not limited to, conjugates between gambogic acid and GA-related and any biological molecule, such as proteins, growth factors and cytokines. Examples include, but are not limited to proteins such as bovine hemoglobin; bovine serum albumin; growth factors such as DGF and NGF; and cytokines such as IL-2 and IL-4.

**[0201]** Bioconjugates are prepared by any method known to one of ordinary skill in the art. See for example, F. J. Burrows and P. E. Thorpe, "Eradication of large solid tumors in mice with an immunotoxin directed against tumor vasculature," *Proc. Natl. Acad. Sci. USA* 90:8996-9000 (1993); M. Adamczyk, *et al.*, "Characterization of Protein-Hapten Conjugates. 2. Electrospray Mass Spectrometry of Bovine Serum Albumin-Hapten Conjugates," *Bioconjugate Chem.* 7:475-481 (1996); R. B. Greenwald, *et al.*, "PEG Thiazolidine-2-thione, a Novel Reagent for Facile Protein Modification: Conjugation of Bovine Hemoglobin," *Bioconjugate Chem.* 7:638-641 (1996); U.S. Patent Nos. 6,482,601 and 6,462,041; Maragos, C. M., Bennett, G. A., Richard, J. L., *Food & Agricultural Immunology* 9:3-12 (1997) and Azcona-Olivera, J. I., Abouzied, M. M., Plattner, R. D., Norred, W. P., Pestka, J. J., *Appl. & Environ. Microbiol.* 58:169-173 (1992). The above immunogens or bioconjugates are illustrative examples only, and any protein or polyamino acid may also be used as the carrier in a manner apparent to a person skilled in the art.

[0202] Sheep, goats and mice can be immunized with the above bioconjugates and antisera can be obtained by methods well known in the art. The antibodies may then be detectably labeled, e.g. with a radiolabel, fluorescence label, enzyme label, biotin, avidin or other label, as described above or according to methods well known in the art. Detection of binding between the test compounds of interest and the antibodies can be done by the homogenous or heterogenous methods as described above, or by any method known in the art.

## VI. Cell-Based Assays

[0203] Another aspect of the present invention relates to a method of identifying AIP binding compounds using cells. Cells with altered (i.e., elevated or reduced) levels of AIP are useful for screening libraries of chemicals and compositions for AIP binding compounds that are apoptotic activating compounds which are potentially useful therapeutically as antineoplastic drugs. Such alteration can be afforded by a variety of techniques known in the art. Such techniques include antisense and RNAi methods, transfection of cells and alteration of the cellular genome.

[0204] Down regulated or reduced expression of an AIP can lead to cellular resistance to apoptosis. Such resistance is manifested, for example, in a cellular culture which is non-responsive to an apoptosis activating composition. Whereas an apoptosis activating composition normally activates the caspase cascade resulting in cell death, non-responsive cells continue to thrive in the presence of such compositions. In contrast, up regulated or elevated levels of an AIP may lead to cells which are more susceptible to apoptosis mediated by AIP binding compounds.

[0205] As described in greater detail below, cellular apoptosis can be monitored by following the growth rate of a cellular culture, microscopically examining cellular structure, or spectroscopically using reporter compounds. Cells with aberrant expression of an AIP can be mixed with test compounds.

The affect of these test compounds is compared amongst cells with elevated, reduced or normal AIP levels to determine those compounds which bind AIP and activate apoptosis.

[0206] Another aspect of the invention relates to a complex, comprising: i) an AIP; and ii) an AIP binding compound; with the proviso that the AIP binding compound is not GA or a GA-related compound. In addition to the above described methods, the ability of a compound to bind an AIP may be determined by creating an FITC-tagged compound according to the examples described below. The AIP and bound FITC-tagged compound are isolated according to the examples described below.

A. Antisense Mediated Down Regulation of AIPs

[0207] The level of AIP expression can be down regulated through the use of antisense nucleotides. An antisense nucleotide is a nucleic acid molecule that interferes with the function of DNA and/or RNA. This may result in suppression of expression. Antisense oligonucleotides also include any natural or modified oligonucleotide or chemical entity that binds specifically to a pre-mRNA or mature mRNA which results in interference or inhibition with translation of the mature mRNA or prevents the synthesis of the polypeptide encoded by the mature mRNA.

[0208] Antisense RNA sequences have been described as naturally occurring biological inhibitors of gene expression in both prokaryotes (Mizuno, T., Chou, M-Y, and Inouye, M. (1984), Proc. Natl. Acad. Sci. USA 81, (1966-1970)) and eukaryotes (Heywood, S. M. Nucleic Acids Res. , 14, 6771-6772 (1986) and these sequences presumably function by hybridizing to complementary mRNA sequences, resulting in hybridization arrest of translation (Paterson, B. M., Roberts, B. E., and Kuff, E. L., (1977) Proc. Natl. Acad. Sci. USA, 74, 4370-4374. Antisense oligodeoxynucleotides are short synthetic nucleotide sequences formulated to be complementary to a specific gene or RNA message. Through the binding of these oligomers to a target

DNA or mRNA sequence, transcription or translation of the gene can be selectively blocked and the disease process generated by that gene can be halted. The cytoplasmic location of mRNA provides a target considered to be readily accessible to antisense oligodeoxynucleotides entering the cell; hence much of the work in the field has focused on RNA as a target. Currently, the use of antisense oligodeoxynucleotides provides a useful tool for exploring regulation of gene expression in vitro and in tissue culture (Rothenberg, M., Johnson, G., Laughlin, C., Green, I., Craddock, J., Sarver, N., and Cohen, J. S.(1989) *J. Natl. Cancer Inst.*, 81:1539-1544.

[0209] The concept behind antisense therapy relies on the ability of antisense oligonucleotides to be taken up by cells and form a stable heteroduplex with the target DNA or mRNA. The end result of antisense oligonucleotide hybridization is the down regulation of the targeted protein's synthesis. Down regulation of protein synthesis by antisense oligonucleotides has been postulated to result from two possible mechanisms: 1) "hybrid arrest," where direct blocking in pre-mRNA and/or mRNA of sequences important for processing or translation prevents full-length proteins from being synthesized; and 2) an RNase H mediated cleavage and subsequent degradation of the RNA portion of the RNA:DNA heteroduplex (Haeuptle, M. et al. (1986) *Nuc. Acids Res.* 14: 1427-1448; Minshull, J. and J. Hunt (1986) *Nuc. Acids Res.* 14: 6433-6451). Down regulation of a protein is functionally equivalent to a decrease in its activity. U.S. Patent Nos. 5, 580,969; 5,585,479; and 5,596,090 describe antisense techniques which can be used in the down regulation of AIPs.

[0210] Antisense oligonucleotides include S-oligos (nucleoside phosphorothioates) which are isoelectronic analogs of an oligonucleotide (O-oligo) in which a nonbridging oxygen atom of the phosphate group is replaced by a sulfur atom. S-oligos may be prepared by treatment of the corresponding O-oligos with 3H-1,2-benzodithiol-3-one-1,1-dioxide which is a sulfur transfer reagent. See Iyer, R.P. et al., *J. Org. Chem.* 55:4693-4698 (1990) ; and Iyer, R. P. et al., *J. Am. Chem. Soc.* 112:1253-1254 (1990). Antisense



oligonucleotides also include such derivatives as described in U.S. Patent Nos. 6,031,086, 5,929,226, 5,886,165, 5,693,773, 6,054,439, 5,919,772, 5,985,558, 5,595,096, 5,916,807, 5,885,970, 5,877,309, 5,681,944, 5,602,240, 5,596,091, 5,506,212, 5,521,302, 5,541,307, 5,510,476, 5,514,787, 5,543,507, 5,512,438, 5,510,239, 5,514,577, 5,519,134, 5,554,746, 5,276,019, 5,286,717, 5,264,423, as well as WO96/35706, WO96/32474, WO96/29337 (thiono triester modified antisense oligodeoxynucleotide phosphorothioates), WO94/17093 (oligonucleotide alkylphosphonates and alkylphosphothioates), W094/08004 (oligonucleotide phosphothioates, methyl phosphates, phosphoramidates, dithioates, bridged phosphorothioates, bridge phosphoramidates, sulfones, sulfates, ketos, phosphate esters and phosphorobutylamines (van der Krol et al., Biotech. 6:958-976 (1988); Uhlmann et al., Chem. Rev. 90:542-585 (1990)), W094/02499 (oligonucleotide alkylphosphonothioates and arylphosphonothioates), and WO92/20697 (3'-end capped oligonucleotides). Further, useful antisense oligonucleotides include derivatives such as S-oligonucleotides (phosphorothioate derivatives or S-oligos, see, Jack Cohen, Oligodeoxynucleotides, Antisense Inhibitors of Gene Expression, CRC Press (1989) which can be prepared, e.g., as described by Iyer et al. (J. Org. Chem. 55:4693-4698 (1990) and J. Am. Chem. Soc. 112:1253-1254 (1990)).

- [0211] Antisense oligonucleotides may be coadministered with an agent which enhances the uptake of the antisense molecule by the cells. For example, the antisense oligonucleotide may be combined with a lipophilic cationic compound which may be in the form of liposomes. Methods of formulating antisense nucleotides with compositions to facilitate introduction of the antisense nucleotides into cells is disclosed, for example, in U.S. Pat. Nos. 4,897,355, 4,394,448, 4,235,871, 4,231,877, 4,224,179, 4,753,788, 4,673,567, 4,247,411, 4,814,270, 5,279,833, and 5,753,613; Published International Application Document WO 00/27795; and in published U.S. Patent Application 2002/0086849. Alternatively, the antisense oligonucleotide may be combined with a lipophilic carrier such as any one of a number of sterols including cholesterol, cholate and deoxycholic acid.

[0212] The antisense oligonucleotide may be conjugated to a peptide that is ingested by cells. Examples of useful peptides include peptide hormones, cell surface receptor ligands, antigens or antibodies, and peptide toxins. By choosing a peptide that is selectively taken up by the cells, specific delivery of the antisense agent may be effected. The antisense oligonucleotide may be covalently bound via the 5'H group by formation of an activated aminoalkyl derivative. The peptide of choice may then be covalently attached to the activated antisense oligonucleotide via an amino and sulfhydryl reactive hetero bifunctional reagent. The latter is bound to a cysteine residue present in the peptide. Upon exposure of cells to the antisense oligonucleotide bound to the peptide, the peptidyl antisense agent is endocytosed and the antisense oligonucleotide binds to the target AIP mRNA to inhibit translation. See PCT Application Publication No. PCT/US89/02363.

[0213] The antisense oligonucleotide may be at least a 15-mer that is complementary to a nucleotide molecule coding for an AIP as described herein. The antisense oligonucleotides of the present invention may be prepared according to any of the methods that are well known to those of ordinary skill in the art. The antisense oligonucleotides may be prepared by solid phase synthesis. See, Goodchild, J., Bioconjugate Chemistry, 1:165-167 (1990), for a review of the chemical synthesis of oligonucleotides. Alternatively, the antisense oligonucleotides can be obtained from a number of companies which specialize in the custom synthesis of oligonucleotides.

[0214] Methods within the scope of this invention include those wherein the antisense oligonucleotide is used in an amount which is effective to achieve inhibition of AIP expression in cells. Determination of effective amounts of each component is within the skill of the art.

#### B. RNA Interference (RNAi) Mediated Down Regulation of AIPs

[0215] Methods employing interfering RNA ("RNAi") use double stranded RNA that results in catalytic degradation of specific mRNAs, and can also be

used to lower gene expression. See U.S. Patent Nos. 6,458,382, 6,506,559 and 6,511,824. In this method, complementary sense and antisense RNAs derived from a portion of a gene of interest are synthesized in vitro using techniques well known in the art. The resulting sense and antisense RNAs are annealed in a buffer, and the double stranded RNA is introduced into the cell.

[0216] As described in U.S. Patent No. 6,515,109, RNAi is the process of sequence-specific, post-transcriptional gene silencing in animals and plants, initiated by double-stranded RNA (dsRNA) that is homologous in sequence to the silenced gene. Methods relating to the use of RNAi to silence genes in *C. elegans*, *Drosophila*, plants, and mammals are known in the art (Fire A, *et al.*, *Nature* 391:806-811 (1998); Fire, A., *Trends Genet.* 15:358-363 (1999); Sharp, P. A. RNA interference 2001. *Genes Dev.* 15, 485-490 (2001); Hammond, S. M., et al., *Nature Rev. Genet.* 2, 110-1119 (2001); Tuschl, T. *Chem. Biochem.* 2, 239-245 (2001); Hamilton, A. et al., *Science* 286, 950-952 (1999); Hammond, S. M., et al., *Nature* 404, 293-296 (2000); Zamore, P. D., et al., *Cell* 101, 25-33 (2000); Bernstein, E., et al., *Nature* 409, 363-366 (2001); Elbashir, S. M., et al., *Genes Dev.* 15, 188-200 (2001); WO0129058; WO9932619, and Elbashir S M, et al., 2001 *Nature* 411:494-498). U.S. Patent No. 6,511,824, also describes RNAi mediated loss-of-function phenotypes.

[0217] RNAi-mediated inhibition of gene expression refers to the absence (or observable decrease) in the level of protein and/or mRNA product from a target gene. Specificity refers to the ability to inhibit the target gene without manifest effects on other genes of the cell. The consequences of inhibition can be confirmed by examination of the outward properties of the cell or organism or by biochemical techniques such as RNA solution hybridization, nuclease protection, Northern hybridization, reverse transcription, gene expression monitoring with a microarray, antibody binding, enzyme linked immunosorbent assay (ELISA), Western blotting, radioimmunoassay (RIA), other immunoassays, and fluorescence activated cell analysis (FACS). For RNAi-mediated inhibition in a cell line, gene expression is conveniently assayed by use of a reporter or drug resistance gene whose protein product is

easily assayed. Such reporter genes include acetohydroxyacid synthase (AHAS), alkaline phosphatase (AP), beta galactosidase (LacZ), beta glucuronidase (GUS), chloramphenicol acetyltransferase (CAT), green fluorescent protein (GFP), horseradish peroxidase (HRP), luciferase (Luc), nopaline synthase (NOS), octopine synthase (OCS), and derivatives thereof. Multiple selectable markers are available that confer resistance to ampicillin, bleomycin, chloramphenicol, gentamycin, hygromycin, kanamycin, lincomycin, methotrexate, phosphinothricin, puromycin, and tetracyclin.

[0218] RNAi mediated down regulation is affected by double stranded RNA sequences identical to a portion of the target. Accordingly, double strand RNA sequences comprise a first strand that encodes an AIP as described herein and a second strand complementary to the first strand. Alternatively, the double strand RNA comprises a first strand identical to the nucleotides described herein and a second strand complementary to the first strand. The skilled artisan recognizes that an RNA sequence is identical to a DNA sequence even though i) the ribose portion is not deoxyribose as in DNA, and ii) the nucleotide pyrimidine base thymine (usually found in DNA) is replaced by uracil. The double-stranded structure may also be formed by a single self-complementary RNA strand.

[0219] The double stranded RNA can have insertions, deletions, and single point mutations relative to the target sequence. Thus, sequence identity may be optimized by sequence comparison and alignment algorithms known in the art (see Gribskov and Devereux, Sequence Analysis Primer, Stockton Press, 1991, and references cited therein) and calculating the percent difference between the nucleotide sequences by, for example, the Smith-Waterman algorithm as implemented in the BESTFIT software program using default parameters (e.g., University of Wisconsin Genetic Computing Group). In one embodiment there is more than 90% sequence identity, or even 100% sequence identity, between the inhibitory RNA and the portion of the target gene. Alternatively, the duplex region of the RNA may be defined functionally as a nucleotide sequence that is capable of hybridizing with a portion of the

target gene transcript (e.g., 400 mM NaCl, 40 mM PIPES pH 6.4, 1 mM EDTA, 50 °C or 70 °C hybridization for 12-16 hours; followed by washing). The length of the identical nucleotide sequences may be at least 25, 30, 35, 40, 45, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 400, 500, 600, 700, 800, 900, 1000 or more bases. 100% sequence identity between the RNA and the target gene is not required. Thus the invention has the advantage of being able to tolerate sequence variations that might be expected due to genetic mutation, strain polymorphism, or evolutionary divergence.

[0220] The RNA may include modifications which are well known in the art to either the phosphate-sugar backbone or the nucleosides. For example, the phosphodiester linkages of natural RNA may be modified to include at least one of a nitrogen or sulfur heteroatom. Modifications in RNA structure may be tailored to allow specific genetic inhibition. Likewise, bases may be modified to block the activity of adenosine deaminase. RNA may be produced enzymatically or by partial/total organic synthesis, any modified ribonucleotide can be introduced by in vitro enzymatic or organic synthesis.

#### C. Altering AIP Expression via Transfection

[0221] The skilled artisan will readily recognize that the expression level of AIPs can be increased using any of the techniques described above in section IV. Expression Vectors and Transfected Cells. Altering AIP expression via transfection can also be done according to the methods of U.S. Patent Nos. 4,980,281; 5,266,464; 5,688,655 and 5,877,007.

[0222] Such methods involve the insertion of a polynucleotide sequence encoding an AIP into an appropriate vector and the generation of cell lines which contain either (1) the expression vector alone ("control" cell lines) or (2) the expression vector containing the inserted polynucleotide (e.g., cDNA) sequence encoding the AIP. Using the appropriate vector system, recipient cell lines, and growth conditions, test cell lines can thus be generated which stably overproduce the corresponding AIP. Under the appropriate growth conditions,

these cell lines will exhibit a "graded cellular response" to activators of the AIP. A graded cellular response is an increase in the phenotypic change exhibited by the cell which becomes greater with increasing expression of the AIP. It is by this specialized response that activators of apoptosis via AIP binding can be distinguished from agents that act upon other cell metabolites to effect a phenotypic change. A screening system can thus be set up whereby the control and test cell lines are propagated in defined growth conditions in tissue culture dishes (or even in experimental animals) and large numbers of compounds (or crude substances which may contain active compounds) can be screened for their ability to bind AIP and activate apoptosis.

[0223] Substances which bind to one or more AIPs and activate apoptosis may affect characteristics such as growth rate, tumorigenic potential, anti-tumorigenic potential, anti-metastatic potential, cell morphology, antigen expression, and/or anchorage-independent growth capability. Substances which specifically bind one or more AIPs and activate apoptosis may be distinguished from substances which affect cell morphology or growth by other mechanisms in that they will have a greater effect on the test lines than on the control lines.

#### D. Altering AIP Expression at the Genomic Level

[0224] Another aspect of the present invention involves altering the level of AIP expression at the genomic level. A gene encoding an AIP is one that can be mutated to have aberrant expression, altered expression, modified expression, or mis-expression due to gene mutations, or mutations upstream or downstream of the gene. Thus, a misexpressed protein may be one having an amino acid sequence that differs from wild-type (e.g. by amino acid substitution or deletion). These terms also include ectopic expression (e.g. by altering the normal spatial or temporal expression), over-expression (e.g. by multiple gene copies), under expression, and non-expression (e.g. by gene

knockout or blocking expression that would otherwise normally occur, for example, by using antisense or RNA interference).

**[0225]** Such methods may involve operably associating an endogenous AIP encoded nucleotide sequence with a promoter via homologous recombination as described, for example, in U.S. Pat. No. 5,641,670, issued Jun. 24, 1997; International Publication Number WO 96/29411, published Sep. 26, 1996; International Publication Number WO 94/12650, published Aug. 4, 1994; Koller et al., Proc. Natl. Acad. Sci. USA 86:8932-8935 (1989); and Zijlstra et al., Nature 342:435-438 (1989). This method involves the activation of a gene which is present in the target cells, but which is not expressed in the cells, or is expressed at a lower level than desired. Polynucleotide constructs are made which contain a promoter and targeting sequences, which are homologous to the 5' non-coding sequence of the endogenous AIP encoding nucleotide, flanking the promoter. The targeting sequence will be sufficiently near the 5' end of the AIP encoding nucleotide so the promoter will be operably linked to the endogenous sequence upon homologous recombination. The promoter and the targeting sequences can be amplified using PCR. The amplified promoter may contain distinct restriction enzyme sites on the 5' and 3' ends. The 3' end of the first targeting sequence may contain the same restriction enzyme site as the 5' end of the amplified promoter and the 5' end of the second targeting sequence may contain the same restriction site as the 3' end of the amplified promoter.

**[0226]** The amplified promoter and the amplified targeting sequences are digested with the appropriate restriction enzymes and subsequently treated with calf intestinal phosphatase. The digested promoter and digested targeting sequences are added together in the presence of T4 DNA ligase. The resulting mixture is maintained under conditions appropriate for ligation of the two fragments. The construct is size fractionated on an agarose gel then purified by phenol extraction and ethanol precipitation.

**[0227]** As in the methods involving transfecting cells with AIP expression vectors, a graded cellular response is used to detect AIP binding agents which

activate apoptosis. Specifically, the affect of a test compound on a test cell with a elevated or normal level of AIP expression is determined by comparison to the affect of a test compound on a control cell having respectively a normal or reduced level of AIP expression. As described above, test compounds which bind to an AIP and activate apoptosis may affect characteristics such as growth rate, tumorigenic potential, anti-tumorigenic potential, anti-metastatic potential, cell morphology, antigen expression, cell cycle and/or anchorage-independent growth capability. Substances which specifically bind an AIP and activate apoptosis may be distinguished from substances which affect cell morphology, cell cycle or growth by other mechanisms in that they will have a greater effect on the test lines than on the control lines.

#### E. Identifying Compounds That Activate the Caspase Cascade

[0228] The invention relates to a method for identifying potentially therapeutically effective antineoplastic compounds wherein a test compound is determined to have potential therapeutic efficacy if said caspase cascade activity is enhanced in response to the presence of said test compound, the method comprising (a) obtaining viable cultured eukaryotic cells expressing AIP (and optionally expresses a cancer phenotype) by culturing those cells in a cell growth medium under conditions which result in growth; (b) exposing the viable cultured cells to a test compound for a predetermined period of time at a predetermined temperature; (c) adding a reporter compound having at least one measurable property which is responsive to the caspase cascade; (d) measuring the caspase cascade activity of said exposed viable cultured cells by measuring said at least one measurable property of said reporter compound; and (e) wherein an increase in the measured caspase cascade activity in the presence of the test compound is an indication that the test compound is a potentially therapeutically effective antineoplastic compound.



**[0229]** In one embodiment, two populations of cells are screened in parallel.

A first population expresses an elevated level of AIP relative to a second population. Where the first population of cells are cells that up regulate AIP, the second population of cells can be normal cells or cells which down regulate AIP (mediated, for example, by antisense nucleotides, RNAi, or altered genes). Where the first population of cells are normal cells, the second population of cells can be cells which down regulate AIP. The first and second population are separately exposed to the test compound and the reporter molecule which gives rise to a measurable property upon activation of the caspase cascade. Any increase in the reporter compound's measurable property in the first population relative to the second population is an indication that the test compound binds AIP, activates the caspase cascade, and is a potentially therapeutic antineoplastic compound.

**[0230]** The skilled artisan will recognize that cells with up regulated levels of AIP are expected to be more susceptible to apoptosis activated by a composition which binds to these polypeptides than are normal cells or cells which down regulate AIP. Likewise, the skilled artisan will recognize that normal cells are expected to be more susceptible to apoptosis activated by a composition which binds to these polypeptides than are cells with down regulated AIP. Hence, the first population of cells can be normal cells which neither up regulate or down regulate AIP and the second population of cells can be those which down regulate AIP.

**[0231]** In contrast to screening methodology using reporter compounds, the ability of a test compound to activate apoptosis can be monitored by microscopically observing changes in cellular morphology. As described in U.S. Patent No. 6,274,309, cells can, in conjunction with the screening techniques described above, be assayed for apoptotic morphology using standard techniques well known to those of skill in the art. Among the characteristics of apoptotic morphology are cellular condensation, nuclear condensation, including chromatin condensation, and the apoptotic characteristic plasma membrane ruffling and blebbing referred to as "zeiosis"

See Sanderson, C. J., 1982, in *Mechanisms of Cell-Mediated Cytotoxicity*, Clark, W. R. & Golstein, R., eds., Plenum Press, pp. 3-21; Godman, G. C. et al., 1975, *J. Cell Biol.* 64:644-667. For example, morphologic changes characteristic of nuclear apoptosis can be assayed and quantified by staining using a DNA-specific fluorochrome such as bis-benzimide (Hoechst-33258; Sigma according to standard methods. See Bose, et al., 1995, *Cell* 82:405-414.

[0232] As described by U. S. Patent No. 5,932,418, DNA fragmentation is another morphological change indicative of apoptosis. DNA fragmentation may be detected with the terminal transferase assay (TUNEL; Thiry M., 1992, Highly sensitive immunodetection of DNA on sections with exogenous terminal deoxynucleotidyl transferase and non-isotopic nucleotide analogues; *J. Histochem. Cytochem.* 40:419-441; Gavrieli Y, Sherman Y and Ben-Sasson SA; 1992, Identification of programmed cell death in situ-via specific labeling of nuclear DNA fragmentation; *J. Cell Biol.* 119:493-501). The TUNEL assay is used to detect 3'OH termini of nicked or broken DNA strands. These nicks or breaks may be generated directly by activating apoptosis. *In vivo*, apoptosis can be assayed via, for example, DNA terminal transferase nick-end translation, or TUNEL assay, according to standard techniques. See Fuks, Z. et al., 1995, *Cancer J.* 1:62-72.

[0233] Accordingly, the present invention relates to a screening method for identifying potentially therapeutically effective antineoplastic compounds by determining the ability of test compounds to alter cellular morphology in cultured eukaryotic cells expressing AIP wherein a test compound is determined to have potential therapeutic efficacy if the cellular morphology is altered in response to the presence of said test compound, the method comprising (a) obtaining cultured eukaryotic cells expressing AIP (and optionally expresses a cancer phenotype) by culturing those cells in a cell growth medium under conditions which result in growth; (b) exposing the viable cultured cells to a test compound for a predetermined period of time at a predetermined temperature; (c) microscopically examining the cellular

morphology; and (d) wherein morphological changes indicative of apoptosis in the presence of the test compound is an indication that the test compound is a potentially therapeutically effective antineoplastic compound.

[0234] In another embodiment, two populations of cells are screened in parallel. A first population expresses an elevated level of AIP relative to a second population. Where the first population of cells are cells that up regulate AIP, the second population of cells can be normal cells or cells which down regulate AIP (mediated, for example, by antisense nucleotides, RNAi, or altered genes). Where the first population of cells are normal cells, the second population of cells can be cells which down regulate AIP. The first and second population are separately exposed to the test compound and the reporter molecule which gives rise to a measurable property upon activation of the caspase cascade. Any increase in the reporter compound's measurable property in the first population relative to the second population is an indication that the test compound binds AIP, activates the caspase cascade, and is a potentially therapeutic antineoplastic compound.

[0235] In contrast to screening methodology by microscopically observing changes in cellular morphology, the ability of a test compound to activate apoptosis can be monitored by following cellular culture growth. Such a screening method relates to a method of identifying potentially therapeutically effective antineoplastic compounds by determining the ability of test compounds to inhibit cellular culture growth in eukaryotic cells expressing an AIP wherein a test compound is determined to have potential therapeutic efficacy if the cellular culture growth is inhibited in response to the presence of said test compound, the method comprising (a) obtaining cultured eukaryotic cells expressing the AIP (and optionally expresses a cancer phenotype) by culturing those cells in a cell growth medium under conditions which result in growth; (b) exposing the cultured cells to a test compound for a predetermined period of time at a predetermined temperature; (c) following the rate of culture growth; and (d) wherein a decrease in culture growth rate in

the presence of the test compound is an indication that the test compound is a potentially therapeutically effective antineoplastic compound.

**[0236]** In another embodiment, two populations of cells are screened in parallel. A first population expresses an elevated level of an AIP relative to a second population. Where the first population of cells are cells that up regulate the AIP, the second population of cells can be normal cells or cells which down regulate the AIP (mediated, for example, by antisense nucleotides, RNAi, or altered genes). Where the first population of cells are normal cells, the second population of cells can be cells which down regulate the AIP. The first and second population are separately exposed to the test compound and the reporter molecule which gives rise to a measurable property upon activation of the caspase cascade. Any increase in the reporter compound's measurable property in the first population relative to the second population is an indication that the test compound binds the AIP, activates the caspase cascade, and is a potentially therapeutic antineoplastic compound.

**[0237]** Any of the methodologies discussed in this section can be performed side-by-side with control cells. Hence, in respect to the above described method employing reporter compounds, the invention also relates to a method for assaying the potency of a potentially therapeutically effective antineoplastic compound that functions as an activator of the caspase cascade in viable cultured eukaryotic cells having an intact cell membrane and expressing an AIP comprising: (a) obtaining a first and a second population of viable cultured eukaryotic cells, each of which has an intact cell membrane and each of which expresses the AIP (and optionally expresses a cancer phenotype), by culturing said eukaryotic cells in a cell growth medium under conditions which result in growth; (b) exposing the first population to a predetermined amount of a test compound for a predetermined period of time at a predetermined temperature; (c) exposing the second population to an amount of solvent that was used to dissolve the test compound for the predetermined period of time at the predetermined temperature; (d) adding to said test compound-exposed first population and said solvent-exposed second

population a reporter compound having at least one measurable property which is responsive to the caspase cascade; (e) measuring said at least one measurable property of said reporter compound in said test compound-exposed first population and thereby measuring the caspase cascade activity of the test compound-exposed first population; (f) measuring said at least one measurable property of said reporter compound in said solvent-exposed second population and thereby measuring the caspase cascade activity of the solvent-exposed second population; and (g) calculating the ratio of caspase cascade activity measured for the test compound-exposed first population of cells to the caspase cascade activity measured for the solvent-exposed second population of cells to determine the relative potency of the test compound as an activator of the caspase cascade. The skilled artisan will recognize that such side-by-side screening can be modified to accommodate the above described screening methodologies which utilize microscopic observations of changes in cellular morphology, cell cycle or observations of cellular culture growth rate. Because these modified assays do not follow caspase cascade activation, they do not require addition of a reporter compound.

[0238] The caspase cascade activity measured for test compounds by this method can also be compared to that measured for compounds which are known to affect enzymes involved in the apoptosis cascade to generate a measure of the relative effectiveness of the test substance. Compounds that can be used in comparison include known activators of enzymes involved in the apoptosis cascade. Known activators, either by direct or indirect mechanisms, of enzymes involved in the apoptosis cascade include but are not limited to vinblastine, etoposide (Yoon, H.J., *et al.*, *Biochim. Biophys. Acta.* 1395:110-120 (1998)) and doxorubicin (Gamen, S., *et al.*, *FEBS Lett.* 417:360-364 (1997)) which are topoisomerase II inhibitors; cisplatin (Maldonado *et al.*, *Mutat. Res.* 381:67-75 (1997)); chlorambucil (Hickman, J.A., *Cancer Metastasis Rev.* 11:121-139 (1992)) which is an alkylating agent; and fluorouracil, an RNA/DNA anti-metabolite (Hickman, J.A., *Cancer Metastasis Rev.* 11:121-139 (1992)).

[0239] In a preferred embodiment, a plurality of viable cultured cells are exposed separately to a plurality of test compounds, e.g. in separate wells of a microtiter plate. In this embodiment, a large number of test compounds may be screened at the same time.

[0240] In another aspect, the invention relates to a method for assaying the potency of a test compound to synergise with other cancer chemotherapeutic agents as an activator of the caspase cascade, comprising (a) obtaining a first and a second population of viable cultured eukaryotic cells, each of which has an intact cell membrane and expresses AIP (and optionally expresses a cancer phenotype), by culturing the cell populations in a cell growth medium under conditions which result in growth; (b) exposing the first population to a combination of a predetermined amount of a test compound and a subinducing amount of a known cancer chemotherapeutic agent for a first predetermined period of time at a first predetermined temperature; (c) exposing the second population to an equal amount of solvent, which was used to dissolve the test compound, and a subinducing amount of a known cancer chemotherapeutic agent for said first predetermined period of time at said first predetermined temperature; (d) adding a reporter compound to the exposed first population and to the exposed second population, the reporter compound having at least one measurable property which is responsive to the caspase cascade; (e) incubating the resulting mixture of the first population, the test compound, the known cancer chemotherapeutic agent and the reporter compound for a second predetermined time period at a second predetermined temperature; (f) incubating the resulting mixture of said second population, said solvent, said known chemotherapeutic agent, and said reporter compound for a second predetermined time period at a second predetermined temperature; (g) measuring said at least one measurable property of said reporter compound in said first resulting mixture and thereby measuring the caspase cascade activity of the first population in the first resulting mixture; (h) measuring said at least one measurable property of the reporter compound in the second resulting mixture and thereby measuring the caspase cascade activity of the second

population in the second resulting mixture; and (i) calculating the ratio of the caspase cascade activity of the first resulting mixture to the caspase cascade activity of the second resulting mixture to determine whether said test compound acts synergistically with the known cancer chemotherapeutic agent. The skilled artisan will recognize that such side-by-side screening can be modified to accommodate the above described screening methodologies which utilize microscopic observations of changes in cellular morphology, cell cycle or observations of cellular culture growth rate. Because these modified assays do not follow caspase cascade activation, they do not require addition of a reporter compound.

[0241] The assays described in this section can also be used to screen for compositions that are selective for cell or tissue type. Such methodologies comprise side-by-side comparisons screening the affect of a given test compound on one cell or tissue type as compared to other cell or tissue types. In such an embodiment, cultures of each of the compared cell or tissue types comprise cells having elevated levels of expression of one or more AIPs. Hence, the invention also relates to a method for assaying the cell or tissue selectivity of a potentially therapeutically effective antineoplastic compound that functions as an activator of the caspase cascade in viable cultured eukaryotic cells having an intact cell membrane and expressing elevated levels of an AIP comprising: (a) obtaining a first population of viable cultured eukaryotic cells, each of which has an intact cell membrane and each of which expresses elevated levels of the AIP, by culturing said eukaryotic cells in a cell growth medium under conditions which result in growth; (b) obtaining a second population of viable cultured eukaryotic cells, each of which having an intact cell membrane and expressing elevated levels of the AIP by culturing said eukaryotic cells in a cell growth medium under conditions which result in growth; (c) separately exposing the first and second populations to a predetermined amount of a test compound for a predetermined period of time at a predetermined temperature; (d) adding to said first and second populations a reporter compound having at least one measurable property

which is responsive to the caspase cascade; (e) measuring said at least one measurable property of said reporter compound in said first and second populations thereby measuring the caspase cascade activity of the first population relative to the second population; (f) calculating the ratio of caspase cascade activity measured for the first population of cells to the caspase cascade activity measured for the second population of cells to determine the relative cell or tissue type selectivity of the test compound as an activator of the caspase cascade, or the relative cell or tissue type selectivity of the test compound as an AIP binder. For example, the first population of cells can express a cancer phenotype that is not expressed in the second population of cells. Accordingly, this method may be used to identify compounds that while specific for cancerous cells, do not affect non-cancerous cells. The skilled artisan will recognize that such side-by-side screening can be modified to accommodate the above described screening methodologies which utilize microscopic observations of changes in cellular morphology, cell cycle or observations of changes in cellular culture growth rate. Because these modified assays do not follow caspase cascade activation, they do not require addition of a reporter compound.

[0242] The invention further relates to a method to further determine the specificity of anticancer agents by determining the ability of the agent to arrest the cell cycle during a particular phase prior to apoptosis. In this embodiment, a time course of test compound treatment determines the phase of the cell cycle arrest that precedes apoptosis. The G2M, S/G2M and G1 phases are the major phases in the cell cycle when one cell divides to become two daughter cells. The cycle starts from a resting quiescent cell (G0 phase) which is stimulated by growth factors leading to a decision (G1 phase) to replicate its DNA. Once the decision is made, the cell starts replicating its DNA (S-phase) and then into a G2 phase before finally dividing into two daughter cells. Cells which then undergo apoptosis contain fragmented DNA in amounts that are less than in the G1 phase and hence are called sub-G1. Thus, a compound leading to a G1 or G2M or S phase arrest and no apoptosis at 24 hr treatment,



and leading to apoptosis at 48 hr treatment as determined by the presence of a sub-G1 peak, indicates that the test compound arrest the cell cycle at the respective stage before inducing apoptosis. See Sherr, C.J., *Cancer Res.* 60:3689-3695 (2000), for a discussion of cancer cell cycles.

[0243] In another aspect, the invention relates to determining the specificity of a test compound by determining at what phase the cell cycle is arrested by the test compound prior to apoptosis. Determining the specificity of a test compound to arrest the cell cycle during a particular phase prior to apoptosis comprises (a) obtaining at least one population of viable cultured cancer cells having intact cell membranes which have an elevated level of an AIP from a cell growth medium under conditions conducive to growth; (b) combining the at least one population with a predetermined amount of at least one test compound dissolved in a solvent for a predetermined period of time at a predetermined temperature thereby generating a first volume; and (c) determining at what phase the cell cycle is arrested.

[0244] In this embodiment, the cells are incubated with a range of concentrations of test compound (*e.g.* 0.02  $\mu$ M to 5  $\mu$ M) for 6 h under normal growth conditions and control cultures are treated with DMSO vehicle. The cells are then treated *e.g.* for 20 min with 800 nM Syto 16. Cytospin preparations are then prepared and the samples are viewed by fluorescent microscopy using a fluorescein filter set. For each concentration of test compound, the number of mitotic figures are counted and expressed as a percentage of the total number of cells. Three fields from each condition are evaluated and the mean and SEM is calculated and plotted as a function of drug concentration. Another method is to simply stain the nuclei with Propidium Iodide and analyze the DNA content using a Fluorescence Activated Cell Sorter and Cell Quest Software (Becton Dickinson).

[0245] Reporter compounds, as described above, may be used as a means for measuring caspase cascade activity in the whole-cell assays of the present invention. Typical reporter compounds include fluorogenic, chromogenic or chemiluminescent compounds applied to cells or tissues containing cells at a

concentration of about 0.01 nanomolar to about 0.1 molar, or an equivalent amount of a salt or prodrug thereof. A concentration of about 10 micromolar may be used.

[0246] The test compounds may be presented to the cells or cell lines dissolved in a solvent. Examples of solvents include, DMSO, water and/or buffers. DMSO may be used in an amount below 2%. Alternatively, DMSO may be used in an amount of 1% or below. At this concentration, DMSO functions as a solubilizer for the test compounds and not as a permeabilization agent. The amount of solvent tolerated by the cells must be checked initially by measuring cell viability or caspase induction with the different amounts of solvent alone to ensure that the amount of solvent has no effect on the cellular properties being measured.

[0247] Suitable buffers include cellular growth media, for example Iscove's media (Invitrogen Corporation) with or without 10% fetal bovine serum. Other known cellular incubation buffers include phosphate, PIPES or HEPES buffers. One of ordinary skill in the art can identify other suitable buffers with no more than routine experimentation.

[0248] The cells can be derived from any organ or organ system for which it is desirable to find a potentially therapeutically effective antineoplastic compound that functions as an activator of the caspase cascade in viable cultured eukaryotic cells having an intact cell membrane. Cellular genotypes for screening of test compounds include, but are not limited to, cells that are P53 negative, Bcl-2 over expressing, Bcl-xL over expressing, ataxia telangiectasia mutated (e.g. ATCC CRL 7201), multi-drug resistance (e.g. P-glycoprotein over expressing, ATCC CRL-1977), DNA mismatch repair deficiency (e.g., defects in hMSH2, hMSH3, hMSH6, hPMS2, or hPMS1), HL-60 cells (ATCC CCL-240), SH-SY5Y cells (ATCC CRL-2266), and Jurkat cells (ATCC TIB-152), surviving over expressing (e.g. ATCC CCL-185), bcr/abl mutated (eg ATCC CCL-243), p16 mutated, Brca1 mutated (e.g. ATCC CRL-2336), or Brca2 mutated. These and other cells may be obtained from the American Type Culture Collection, Manassas, VA.

**[0249]** Suitable solubilizers may be used for presenting reporter compounds to cells or cell lines. Solubilizers include aqueous solutions of the test compounds in water-soluble form, for example as water-soluble salts. The test compounds may be dissolved in a buffer solution containing 20% sucrose (Sigma) 20 mM DTT (Sigma), 200 mM NaCl (Sigma), and 40 mM Na PIPES buffer pH 7.2 (Sigma).

**[0250]** Inasmuch as the caspase cascade takes place in the intracellular environment, measures may be undertaken to enhance transfer of the reporter compound across the cell membrane. This can be accomplished with a suitable permeabilization agent. Permeabilization agents include, but are not limited to, NP-40, n-octyl-O-D-glucopyranoside, n-octyl-O-D-thioglucopyranoside, taurocholic acid, digitonin, CHAPS, lysolecithin, dimethyldecylphosphine oxide (APO-10), dimethyldodecylphosphine oxide (APO-12), N,N-bis-(3-D-gluconamidopropyl)cholamide (Big Chap), N,N-bis-(3-D-gluconamidopropyl)deoxycholamide (Big Chap, deoxy), BRIG-35, hexaethyleneglycol (C10E6), C10E8, C12E6, C12E8, C12E9, cyclohexyl-n-ethyl-O-D-maltoside, cyclohexyl-n-hexyl-O-D-maltoside, cyclohexyl-n-methyl-O-D-maltoside, polyethylene glycol lauryl ether (Genapol C-100), polyethylene glycol dodecyl ether (Genapol X-80), polyoxyethylene isotridecyl ether (Genapol X-100), n-decanoylsucrose, n-decyl-O-D-glucopyranoside, n-decyl-O-D-maltopyranoside, n-decyl-O-D-thiomaltoside, n-dodecanoylsucrose, n-dodecyl-O-D-glucopyranoside, n-dodecyl-O-D-maltoside, n-heptyl-O-D-glucopyranoside, n-heptyl-O-D-thioglucopyranoside, n-hexyl-O-D-glucopyranoside, n-nonyl-O-D-glucopyranoside, n-octanoylsucrose, n-octyl-O-D-maltopyranoside, n-undecyl-O-D-maltoside, n-octanoyl-O-D-glucosylamine (NOGA), PLURONIC<sup>7</sup> F-127, and PLURONIC<sup>7</sup> F-68.

**[0251]** The cell lines are exposed to a predetermined amount of test compounds at concentrations in the range from about 1 picomolar to about 1 millimolar, or about 1-10 micromolar. The predetermined period of time may

be about 1 minute to less than about 24 hours, or 1-24 hours, or 3, 5, or 24 hours. The predetermined temperature may be about 4 °C to about 50 °C, or about 37 °C.

F. Measuring the Potency of Caspase Cascade Activation

[0252] Using a fluorescent plate reader, an initial reading (T=0) is made immediately after addition of the reporter reagent solution, employing excitation and emission at an appropriate wavelength (preferably excitation at 485 nm and emission at 530 nm) to determine the background absorption and/or fluorescence of the control sample. After the incubation, the absorption and/or fluorescence of the sample is measured as above (e.g., at T = 3hr).

Sample Calculation:

[0253] The Relative Fluorescence Unit values (RFU) are used to calculate the potency of the test compounds as follows:

$$\text{RFU}_{(T=3\text{hr})} - \text{RFU}_{(T=0)} = \text{Net RFU}$$

[0254] The potency of caspase cascade activation is determined by the ratio of the Net RFU value for a test compound to that of control samples as follows:

$$\frac{\text{Net RFU of test compound}}{\text{Net RFU of control sample}} = \text{Ratio}$$

[0255] Preferred test compounds are those indicating a ratio of 2 or greater and most preferably with a measured ratio greater than a statistically significant value calculated as  $(\text{Ave Control RFU} + 4 \times \text{SD}_{\text{Control}}) / (\text{Ave Control RFU})$  for that run.

[0256] Examples of high throughput instrumentation which can be used according to the present invention are well known in the art. Non-limiting

examples of such instruments include ImageTrak® (Packard BioScience), the FLIPR® system, Spectramax Gemini or FMax (Molecular Devices Corporation, Sunnyvale, CA), VIPR™ II Reader (Aurora Biosciences Corporation, San Diego, Ca), Fluoroskan II (GMI, Inc., Albertville, MN), Fluoroskan Ascent (Labsystems, Franklin, MA), Cytofluor or Cytofluor 4000 (Perkin Elmer Instruments), Cytofluor 2300 (Millipore, FLx800TBID, FLx800TBIDE, ELx808, ELx800, FL600 (Bio-Tek Instruments), Spectrafluora, Spectrofluora Plus, Ultra or Polarion (Tecan AG), MFX (Dy nex Technologies, Chantilly, VA), Fluoro Count (Packard Instruments Co.), NOVOstar, POLARstar Galaxy or FLUOstar Galaxy (BMG Lab Technologies GmbH), Fluorolite 1000 (Dy nex Technologies), 1420 Victor 2 (EG&G Wallac, Inc., also available through PerkinElmer), and Twinkle LB 970 (Berthold Technologies GmbH & Co.).

## VII. Diagnosis and Prognosis

[0257] It is believed that certain tissues in mammals with certain diseases (e.g. cancer or autoimmune diseases) express significantly altered (enhanced or decreased) levels of one or more AIPs and mRNA encoding AIP when compared to tissues of a corresponding "standard" mammal, i.e., a mammal of the same species not having the disease. Further, it is believed that altered levels of one or more AIP can be detected in certain body fluids (e.g., sera, plasma, urine, and spinal fluid) from mammals with the disease when compared to sera from mammals of the same species not having the disease. Thus, the invention provides a diagnostic method which involves assaying the expression level of a gene encoding a given AIP in mammalian cells or body fluid and comparing the gene expression level with the gene's standard expression level, whereby an increase or decrease in the gene expression level over the standard expression level is indicative of the disease. The gene's standard expression level can be an average level of expression as determined by measuring the expression level in a given population.

[0258] Where a diagnosis has already been made according to conventional methods, the present invention is useful as a prognostic indicator, whereby patients exhibiting lowered AIP gene expression will experience a worse clinical outcome in response to administration of an AIP binding compound relative to patients expressing AIP at a normal level.

[0259] By "assaying the expression level of a gene encoding a given AIP" is intended qualitatively or quantitatively measuring or estimating the level of AIP or the level of the mRNA encoding a given AIP in a first biological sample either directly (e.g., by determining or estimating absolute protein level or mRNA level) or relatively (e.g., by comparing to the AIP level or mRNA level in a second biological sample). The AIP level or mRNA level in the first biological sample may be measured or estimated and compared to a standard AIP level or mRNA level, the standard being taken from a second biological sample obtained from an individual not having the cancer, or population of individuals not having the cancer. As will be appreciated in the art, once a standard AIP level or mRNA level (for a particular AIP) is known, it can be used repeatedly as a standard for comparison.

[0260] By "biological sample" is intended any biological sample obtained from an individual, cell line, tissue culture, or other source which contains AIP or mRNA encoding AIP. Biological samples include mammalian body fluids (such as sera, plasma, urine, synovial fluid and spinal fluid) which contain secreted AIP, and ovarian, prostate, heart, placenta, pancreas liver, spleen, lung, breast and umbilical tissue.

[0261] Total cellular RNA can be isolated from a biological sample using the single-step guanidinium-thiocyanate-phenol-chloroform method described in Chomczynski and Sacchi, *Anal. Biochem.* 162:156-159 (1987). Levels of mRNA encoding AIP are then assayed using any appropriate method. These include Northern blot analysis, (Harada et al., *Cell* 63:303-312 (1990) S1 nuclease mapping, (Fijita et al., *Cell* 49:357-367 (1987)) the polymerase chain reaction (PCR), reverse transcription in combination with the polymerase

chain reaction (RT-PCR) (Makino et al., Technique 2:295-301 (1990), and reverse transcription in combination with the ligase chain reaction (RT-LCR).

[0262] Assaying AIP levels in a biological sample can be done using antibody-based techniques. For example, AIP expression in tissues can be studied with classical immunohistological methods. (Jalkanen, M., et al., J. Cell. Biol. 101:976-985 (1985); Jalkanen, M., et al., J. Cell. Biol. 105:3087-3096 (1987)).

[0263] Other antibody-based methods useful for detecting AIP gene expression include immunoassays, such as the enzyme linked immunosorbent assay (ELISA) and the radioimmunoassay (RIA).

[0264] Suitable labels are known in the art and include enzyme labels, such as, Glucose oxidase, and radioisotopes, such as iodine ( $^{125}\text{I}$ ,  $^{121}\text{I}$ ), carbon ( $^{14}\text{C}$ ), sulfur ( $^{35}\text{S}$ ), tritium ( $^3\text{H}$ ), indium ( $^{112}\text{In}$ ), and technetium ( $^{99}\text{Tc}$ ), and fluorescent labels, such as fluorescein and rhodamine, and biotin.

#### VIII. Rational Drug Design Using AIP Structure

[0265] As described in U.S. Patent No. 6,150,088, a structure-based approach can be used, along with available computer-based design programs, to identify or design a drug which will fit into, line or bind a cavity or pocket of an AIP. The structures of transferrin receptor are disclosed in Borhani, D.W. and Harrison, S.C., "Crystallization and X-ray diffraction studies of a soluble form of the human transferrin receptor," *J. Mol. Biol.*, 218: 685-9 (1991); and Lawrence, C.M. et al., "Crystal structure of the ectodomain of human transferrin receptor," *Science*, 286: 779-82 (1999). The structures of clathrin heavy chain are disclosed in Kirchhausen T. & Harrison S. C., "Structural domains of clathrin heavy chains," *J. Cell Biol.* 99:1725-1734 (1984); Kirchhausen T. et al., "Clathrin heavy chain: molecular cloning and complete primary structure," *Proc Natl Acad Sci U S A* 84:8805-8809 (1987); Ybe, J. A. et al., "Clathrin self-assembly is mediated by a tandemly repeated superhelix," *Nature* 399: 371-5 (1999); Schmid, S. L., "Clathrin-coated vesicle formation

and protein sorting: an integrated process," *Annu. Rev. Biochem.* 66: 511-548 (1997); Smith C. J. and Pearse, B. M., "Clathrin: anatomy of a coat protein," *Trends Cell Biol.* 9: 335-8 (1999); Ungewickell, E. "Clathrin: a good view of a shapely leg," *Curr. Biol.* 9(1): R32-5 (1999); and ter Haar, E. *et al.*, "Atomic structure of clathrin: a beta propeller terminal domain joins an alpha zigzag linker," *Cell* 95(4): 563-73 (1998). Non-limiting examples of structures for heat shock protein 90 are disclosed in Stebbins C.E. *et al.*, "Crystal structure of an Hsp90-geldanamycin complex: targeting of a protein chaperone by an antitumor agent," *Cell* 89:239-250 (1997); and Obermann W. M. *et al.*, "In vivo function of Hsp90 is dependent on ATP binding and ATP hydrolysis," *J. Cell Biol.* 143:901-910 (1998).

[0266] For example, this method can be carried out by comparing the members of the chemical library with the crystal structure of a the AIP using computer programs known to those of skill in the art (e.g., Dock, Kuntz, I. D. *et al.*, *Science*, 257:1078-1082 (1992); Kuntz, I. D. *et al.*, *J. Mol. Biol.*, 161:269 (1982); Meng, E. C., *et al.*, *J. Comp. Chem.*, 13: 505-524 (1992) or CAVEAT). In this method, the library of molecules to be searched can be any library, such as a database (i.e., online, offline, internal, external) which comprises crystal structures, coordinates, chemical configurations or structures of molecules, compounds or drugs to be assessed or screened for their ability to bind an AIP. For example, databases for drug design, such as the Cambridge Structural Database (CSD), which includes about 100,000 molecules whose crystal structures have been determined or the Fine Chemical Director (FCD) distributed by Molecular Design Limited (San Leandro, Calif.) can be used. See Allen, F. H., *et al.*, *Acta Crystallogr. Section B*, 35:2331 (1979). In addition, a library, such as a database, biased to include an increased number of members which comprise indole rings, hydrophobic moieties and/or negatively-charged molecules can be used.

[0267] A drug or molecule which binds or fits into a cavity or pocket on the surface of an AIP, can be used alone or in combination with other drugs (as part of a drug cocktail) to prevent, ameliorate or treat conditions responsive to

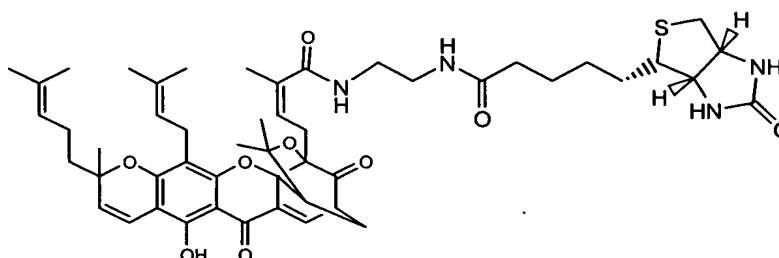


induction of apoptosis. A drug designed or formed by a method described herein is also the subject of this invention.

## EXAMPLES

### EXAMPLE 1

#### *N*-(2-Gambogylaminoethyl)biotinamide

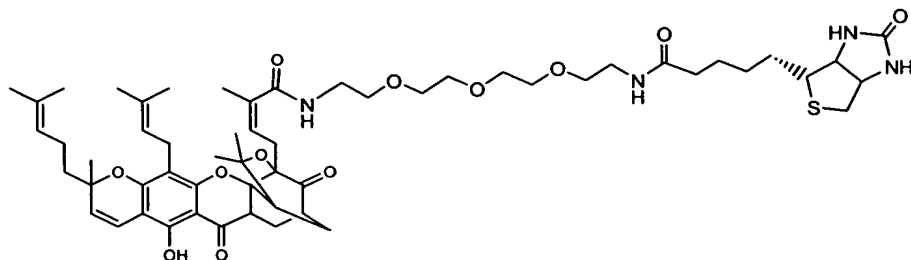


Preparation of *N*-(2-Gambogylaminoethyl)biotinamide:

[0268] A mixture of gambogic acid (85.6 mg, 0.136 mmol), DMAP (19.9 mg, 0.164 mmol), EDC (31.3 mg, 0.164 mmol) and *N*-(2-aminoethyl)biotinamide (Molecular Probes, 50 mg, 0.14 mmol) in DMF (5 mL) was stirred at room temperature for 72 h. The solution was poured into water (50 mL) and was extracted with ethyl acetate (3 x 10 mL). The combined organic layer was dried and concentrated to give crude product, which was purified by chromatography (SiO<sub>2</sub>, EtOAc/MeOH 4:1) to give the title compound (28 mg, 23%). <sup>1</sup>H NMR (CDCl<sub>3</sub>): 12.92(s, 1H), 7.58 (d, *J* = 6.9 Hz, 1H), 7.05-6.90 (m, 2H), 6.68(d, *J* = 9.9 Hz, 1H), 6.15 (bs, 1H), 5.50 (d, *J* = 10.5 Hz, 1H), 5.28 (m, 2H), 5.05 (m, 2H), 4.49 (m, 1H), 4.32 (m, 1H), 3.58-2.00 (m, 14H), 1.77 (bs, 3H), 1.73 (bs, 3H), 1.69 (bs, 6H), 1.65 (bs, 6H), 1.45 (bs, 3H), 1.29 (bs, 3H). MS: 919 (M + Na<sup>+</sup>), 897 (M + H<sup>+</sup>), 895 (M - H<sup>+</sup>).

## EXAMPLE 2

*N*-[2-(2-{2-[2-(9,10-Dihydrogambogyl)aminoethoxy]-ethoxy}-ethoxy)-ethyl]-biotinamide

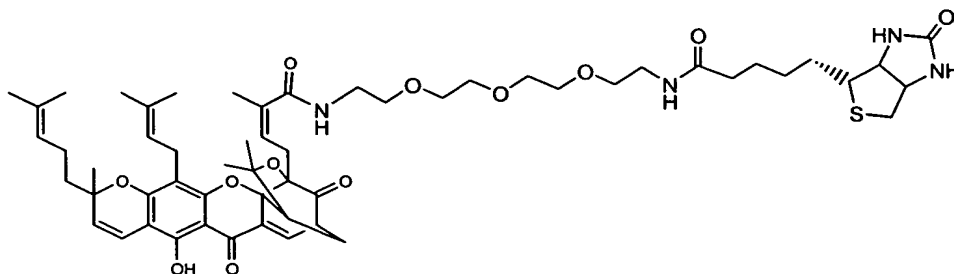


Preparation of *N*-[2-(2-{2-[2-(9,10-Dihydrogambogyl)aminoethoxy]-ethoxy}-ethoxy)-ethyl]-biotinamide:

[0269] A mixture of *N*-hydroxysuccinimidyl 9,10-dihydrogambogate (50 mg, 0.068 mmol), *N*-(2-{2-[2-(2-aminoethoxy)-ethoxy]-ethoxy}-ethyl)-biotinamide (Pierce, 28.8 mg, 0.068 mmol) in dichloromethane (3 mL) was stirred at room temperature for 4 days. The solvent was evaporated and the residue was purified by chromatography (SiO<sub>2</sub>, CH<sub>2</sub>Cl<sub>2</sub>/MeOH 30:1) to give the title compound (11 mg, 16%). <sup>1</sup>H NMR (CDCl<sub>3</sub>): 11.94 (s, 1H), 7.15 (bs, 1H), 6.66 (d, *J* = 9.9 Hz, 1H), 6.50 (bs, 1H), 5.86 (t, *J* = 6.90 Hz, 1H), 5.71 (bs, 1H), 5.46 (d, *J* = 9.9 Hz, 1H), 5.18- 4.90 (m, 2H), 4.51 (m, 1H), 4.33 (m, 1H), 1.94 (s, 3H), 1.73 (s, 3H), 1.68-1.64 (m, 9H), 1.36 (s, 3H), 1.32 (s, 3H), 1.12 (s, 3H). MS: 1032 (M+H), 1054 (M+Na<sup>+</sup>), 1030 (M-H), 1065 (M+Cl-1).

### EXAMPLE 3

*N*-(2-{2-[2-(2-Gambogylaminoethoxy)-ethoxy]-ethoxy}-ethyl)-biotinamide

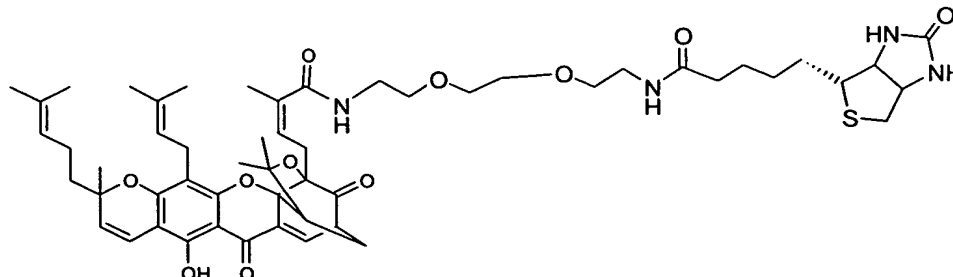


Preparation of *N*-(2-{2-[2-(2-Gambogylaminoethoxy)-ethoxy]-ethoxy}-ethyl)-biotinamide:

[0270] The title compound was prepared by a procedure similar to that of Example 2 from *N*-hydroxysuccinimidyl gambogate and *N*-(2-{2-[2-(2-aminoethoxy)-ethoxy]-ethoxy}-ethyl)-biotinamide (Pierce). Yield: 20%. <sup>1</sup>H NMR (CDCl<sub>3</sub>): 13.0 (s, 1H), 7.67 (d, *J* = 6.6 Hz, 1H), 6.80 (m, 1H), 6.78 (d, *J* = 10.2 Hz, 1H), 5.58 (d, *J* = 10.2 Hz, 1H), 5.15-5.10 (m, 2H), 4.30-4.10 (m, 10H), 3.70-3.15 (m, 3H), 3.00-1.20 (m, 56H). MS: 1029 (M + H), 1051 (M + Na<sup>+</sup>).

### EXAMPLE 4

*N*-(2-[2-(2-Gambogylaminoethoxy)-ethoxy]-ethyl)-biotinamide

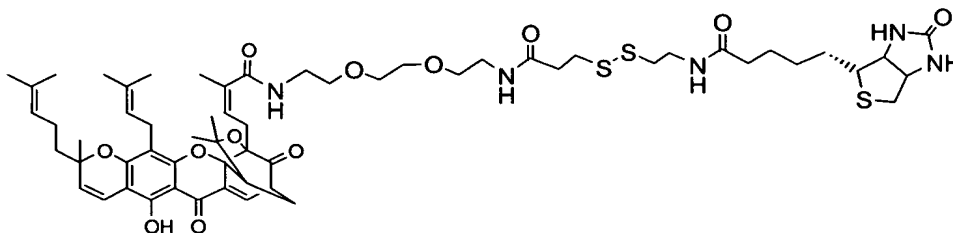


Preparation of *N*-{2-[2-(2-Gambogylaminoethoxy)-ethoxy]-ethyl}-biotinamide:

[0271] The title compound was prepared by a procedure similar to that of Example 2 from *N*-hydroxysuccinimidyl gambogate and *N*-{2-[2-(2-aminoethoxy)-ethoxy]-ethyl}-biotinamide (Pierce). Yield: 29%. <sup>1</sup>H NMR (CDCl<sub>3</sub>): 12.85 (s) and 12.95 (s, 1H), 7.56 (m, 1H), 6.70 (m, 1H), 6.45 (m, 1H), 5.90 (bs, 1H), 5.60-5.30 (m, 2H), 5.20 (bs, 1H), 5.00 (bs, H), 4.60 (bs, 1H), 4.45 (m, 1H), 4.30 (m, 1H), 3.70-3.10 (m, 15H), 3.00-1.20 (m, 45H). MS: 985 (M + H), 983 (M + Na<sup>+</sup>).

#### EXAMPLE 5

*N*-[2-(2-{2-[2-(2-Gambogylaminoethoxy)-ethoxy]-ethylcarbamoyl}-ethylthio)-ethyl]-biotinamide



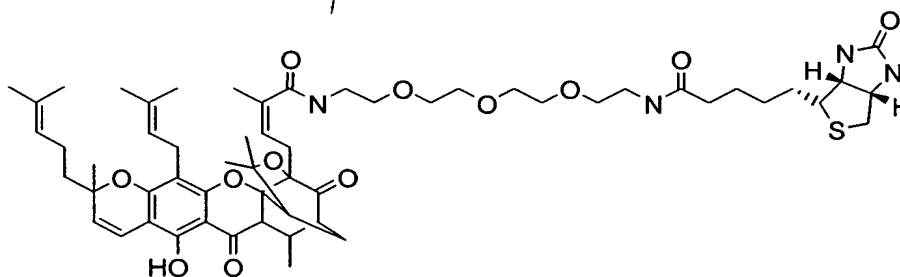
Preparation of *N*-[2-(2-{2-[2-(2-Gambogylaminoethoxy)-ethoxy]-ethylcarbamoyl}-ethylthio)-ethyl]-biotinamide:

[0272] To a solution of *N*-hydroxysuccinimidyl gambogate (120 mg, 0.164 mmol), 2,2'-(ethylenedioxy)bisethylamine (24.1  $\mu$ L, 0.164 mmol) in dichloromethane (1.64 mL) was added a few drops of triethylamine and it was stirred at rt for 2 h, then a solution of sulfo-NHS-SS-biotin (Pierce, 50 mg, 0.0824 mmol) in DMF (1.5 mL) was added and stirred at room temperature for 2 days. The solution was diluted with ethyl acetate (30 ml) and was

washed with water (3 x 20 mL), the organic layer was dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated to give crude residue, which was purified by chromatography (SiO<sub>2</sub>, CH<sub>2</sub>Cl<sub>2</sub>/MeOH 10:1) to give the title compound (59.2 mg, 31%). <sup>1</sup>H NMR (CDCl<sub>3</sub>): 12.85 (s, 1H), 7.56 (d, *J* = 6.9 Hz, 1H), 7.05 (t, *J* = 7.5 Hz, 1H), 6.92 (t, *J* = 7.5 Hz, 1H), 6.68 (bs, 1H), 6.67 (d, *J* = 9.9 Hz, 1H), 5.64 (bs, 1H), 5.46 (d, *J* = 10.5 Hz, 1H), 5.37 (t, *J* = 6.9 Hz, 1H), 5.05 (m, 2H), 4.93 (bs, 1H), 4.50 (t, *J* = 7.5 Hz, 1H), 4.32 (t, *J* = 7.5 Hz, 1H), 1.78 (s, 3H), 1.74 (s, 3H), 1.69 (s, 3H), 1.68-1.60 (m, 9H), 1.55 (s, 3H), 1.44 (s, 3H), 1.28 (s, 3H). MS: 1170 (M+Na<sup>+</sup>), 1148 (M+H<sup>+</sup>), 1182 (M+Cl-1), 1147 (M- H<sup>+</sup>).

#### EXAMPLE 6

*N*-[2-(2-{2-[2-(9,10-Dihydro-10-methyl-gambogyl)aminoethoxy]-ethoxy}-ethoxy)-ethyl]-biotinamide



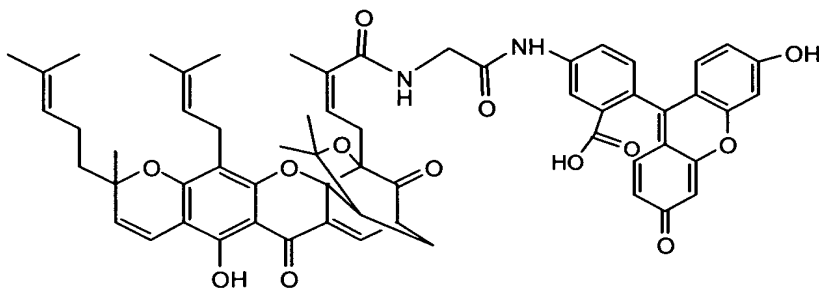
Preparation of *N*-[2-(2-{2-[2-(9,10-Dihydro-10-methyl-gambogyl)aminoethoxy]-ethoxy}-ethoxy)-ethyl]-biotinamide:

**[0273]** To a solution of *N*-hydroxysuccinimidyl 9,10-dihydro-10-methyl-gambogate (57 mg, 0.077 mmol) and *N*-(2-{2-[2-(2-aminoethoxy)-ethoxy]-ethoxy}-ethyl)-biotinamide (Pierce, 32 mg, 0.077 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (3 mL) was added Et<sub>3</sub>N (50 μL). The reaction was stirred at rt for 20 hr. The solvent was evaporated and the residue was purified by column chromatography (SiO<sub>2</sub>, EtOAc:hexanes/10-30% gradient) to give the product (17 mg, 21%): <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>Cl) 12.00 (s, 1H), 7.23 (m, 1H), 6.78 (m, 1H), 6.66 (d, *J*

= 9.9 Hz, 1H), 6.13 (s, 1H), 5.97 (m, 1H), 4.46 (d,  $J = 10.2$  Hz, 1H), 5.20 (s, 1H), 5.12-5.00 (m, 2H), 4.50 (m, 1H), 4.32 (m, 1H), 3.66-3.52 (m, 10H), 3.56 (t,  $J = 4.8$  Hz, 3H), 3.50-3.38 (m, 3H), 3.33 (m, 1H), 3.16 (m, 2H), 2.99 (m, 1H), 2.91 (dd,  $J = 4.5, 12.6$  Hz, 1H), 2.81 (d,  $J = 3.3$  Hz, 1H), 2.78-2.65 (m, 3H), 2.53 (d,  $J = 8.7$  Hz, 1H), 2.30 (dd,  $J = 3.6, 5.1$  Hz, 1H), 2.24 (t,  $J = 7.2$  Hz, 2H), 2.14-2.20 (m, 3H), 1.95 (s, 3H), 1.87 (s, 6H), 1.72 (s, 3H), 1.66 (s, 3H), 1.64 (s, 3H), 1.57 (s, 3H), 1.50-1.40 (m, 3H), 1.38 (m, 1H), 1.35 (s, 3H), 1.34 (s, 3H), 1.38 (s, 3H), 0.98 (d,  $J = 7.2$  Hz, 2H); MS ( $M+1$ ): 1046.

#### EXAMPLE 7

##### 5-(Gambogylaminoacetamido)fluorescein

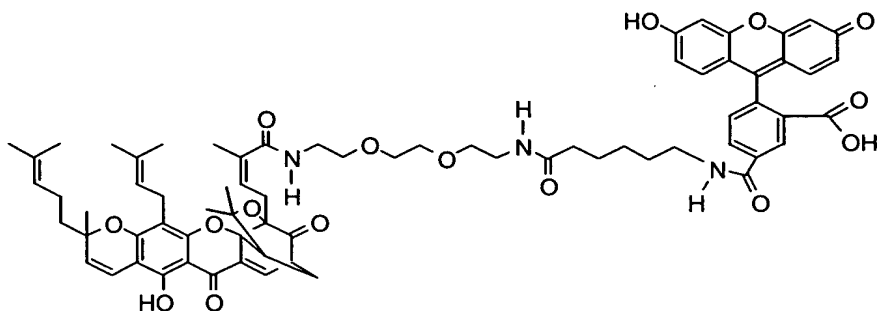


Preparation of 5-(Gambogylaminoacetamido)fluorescein:

[0274] The title compound was prepared by a procedure similar to that of Example 2 from N-hydroxysuccinimidyl gambogate and 5-(aminoacetamido)fluorescein (Molecular Probes). Yield: 22%.  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 8.20-7.60 (m, 10H), 7.20 (m, 1H), 6.80-6.60 (m, 3H), 5.90 (bs, 1H), 5.30-5.00 (m, 2H), 4.20 (m, 2H), 3.80-0.90 (m, 39H). MS: 1015 ( $M + H$ ), 1013 ( $M - H$ ).

### EXAMPLE 8

*N*-(5-{2-[2-(2-Gambogylaminoethoxy)-ethoxy]-ethylcarbamoyl}-pentyl)-fluorescein-5-carboxamide

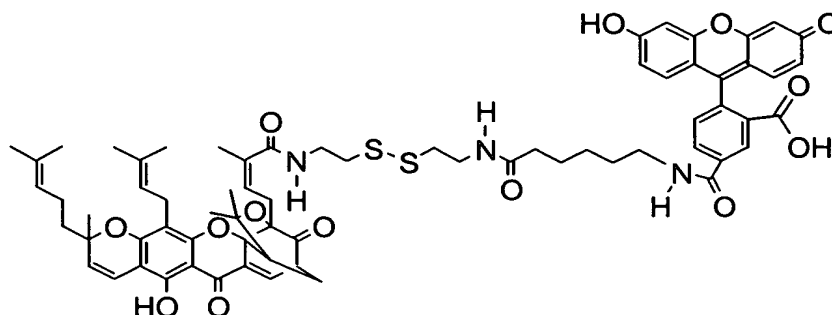


Preparation of *N*-(5-{2-[2-(2-Gambogylaminoethoxy)-ethoxy]-ethylcarbamoyl}-pentyl)-fluorescein-5-carboxamide:

[0275] To a solution of *N*-hydroxysuccinimidyl gambogate (43 mg, 0.059 mmol) in 600  $\mu$ L of dichloromethane was added 2-[2-(2-aminoethoxy)-ethoxy]-ethylamine (8  $\mu$ L, 0.055 mmol) and the mixture was stirred for 3 h. A solution of 6-(fluorescein-5-carboxamido) hexanoic acid succinimidyl ester (Molecular Probes, 30 mg, 0.051 mmol) was added in 900  $\mu$ L of DMF and the mixture was stirred for 6h. The reaction mixture was diluted with ethyl acetate (30 mL), washed with water (2 x 20 mL) and brine (2 x 30 mL), dried over  $\text{MgSO}_4$  and concentrated to give the crude product, which was purified by column chromatography (15% methanol/chloroform) to yield the title compound (13.2 mg, 0.011 mmol, 21%).  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 8.46 (m, 1H), 8.14 (m, 1H), 7.72 (m, 1H), 7.54 (dd,  $J = 6.6$  Hz, 1H), 7.13 (m, 1H), 6.89 (m, 1H), 6.63-6.68 (m, 4H), 6.47 (m, 2H), 5.42-5.47 (m, 2H), 5.03 (m, 2H), 3.20-3.54 (m, 17H), 2.80 (m, 1H), 2.45-2.59 (m, 4H), 2.28 (m, 1H), 1.95-2.13 (m, 5H), 1.24-1.75 (m, 35H). MS,  $[\text{M}+\text{H}]^+ = 1231$ .

### EXAMPLE 9

*N*-{5-[2-(2-Gambogylamino-ethylthio)-ethylcarbamoyl]-pentyl}-fluorescein-5-carboxamide



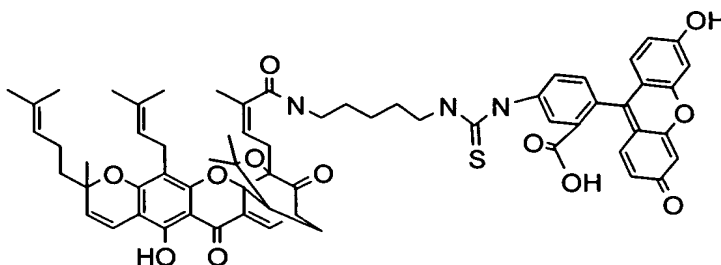
Preparation of *N*-{5-[2-(2-Gambogylamino-ethylthio)-ethylcarbamoyl]-pentyl}-fluorescein-5-carboxamide:

[0276] To a solution of *N*-hydroxysuccinimidyl gambogate (31 mg, 0.044 mmol) and cystein dihydrochloride (9.5 mg, 0.042 mmol) in 500  $\mu$ L of dichloromethane was added 3 drops of triethylamine and stirred for 2h. A solution of 6-(fluorescein-5-carboxamido) hexanoic acid succinimidyl ester (Molecular Probes, 25 mg, 0.043 mmol) in 800  $\mu$ L of DMF was added and the mixture was stirred for 6h. The reaction mixture was diluted with ethyl acetate (30 mL), washed with water (2 x 20 mL) and brine (2 x 30 mL), dried over  $\text{MgSO}_4$ , filtered and concentrated to give the crude product, which was purified by column chromatography (10-15% methanol/dichloromethane) to yield the title compound (5.1 mg, 0.0041 mmol, 10%).  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 8.32 (m, 1H), 8.10 (m, 1H), 7.73 (m, 1H), 7.58 (m, 2H), 7.23 (m, 2H), 7.04 (m, 1H), 6.81 (m, 1H), 6.62 (m, 2H), 5.21 (m, 1H), 5.02 (m, 3H), 3.21-3.61 (m, 4H), 2.21-2.45 (m, 8H), 2.10 (m, 2H), 0.68-1.73 (m, 48H). MS,  $[\text{M}-\text{H}]^- = 1233$ .



### EXAMPLE 10

#### 5-[(5-Gambogylaminopentyl)-thioureidyl]-fluorescein

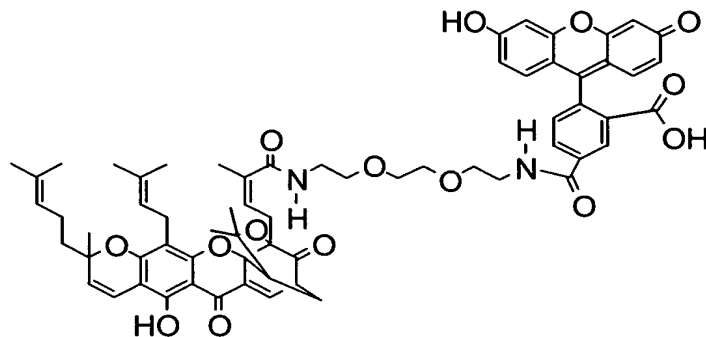


Preparation of 5-[(5-Gambogylaminopentyl)-thioureidyl]-fluorescein:

[0277] To a solution of *N*-hydroxysuccinimidyl gambogate (75 mg, 0.103 mmol) in 1 mL of DMF was added a solution of 5-[(5-aminopentyl)-thioureidyl]-fluorescein dihydrobromide (50 mg, 0.077 mmol) in 1 mL of DMF, followed by 4 drops of triethylamine. The reaction mixture was stirred for 4h and DMF was removed under high vacuum and the residue was purified by column chromatography (20% methanol/chloroform) to obtain the title compound (79 mg, 0.072 mmol, 94%). <sup>1</sup>H NMR (CDCl<sub>3</sub>/MeOH-d<sub>4</sub>): 8.24 (m, 1H), 8.18 (m, 1H), 7.95 (m, 1H), 7.58 (m, 1H), 7.14 (m, 3H), 6.81 (m, 2H), 6.62 (m, 2H), 6.51 (m, 1H), 5.43 (m, 1H), 5.26 (m, 1H), 5.11 (m, 2H), 4.21-4.30 (m, 4H), 3.21-3.62 (m, 4H), 2.61-2.73 (m, 2H), 2.34-2.43 (m, 1H), 2.13-0.89 (m, 35H). MS, [M+H]<sup>+</sup> = 1103.

### EXAMPLE 11

*N*-{2-[2-(2-Gambogylaminoethoxy)-ethoxy]-ethyl}-fluorescein-5-carboxamide

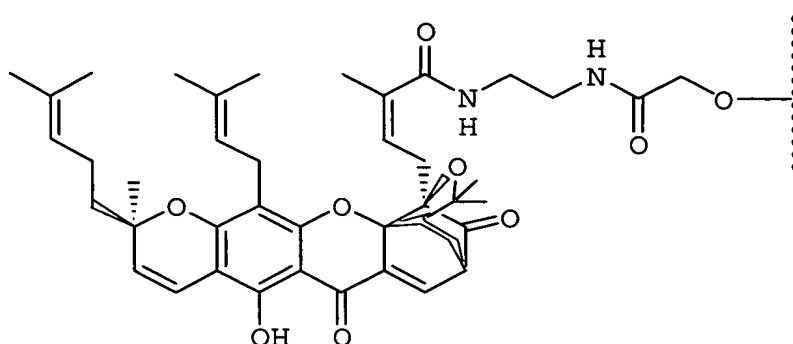


Preparation of *N*-{2-[2-(2-Gambogylaminoethoxy)-ethoxy]-ethyl}-fluorescein-5-carboxamide:

[0278] To a solution of *N*-hydroxysuccinimidyl gambogate (32 mg, 0.045 mmol) in 300  $\mu$ L of dichloromethane was added 2-[2-(2-amino-ethoxy)-ethoxy]-ethylamine (6 mg, 0.040 mmol) and the mixture was stirred for 3 h. To the solution was added 5-Carboxyfluorescein succinimidyl ester (Molecular Probes, 20 mg, 0.042 mmol) in 500  $\mu$ L of DMF and the mixture was stirred for 6 h. The solvents were removed under vacuum and the residue was purified by column chromatography (5-10% methanol/chloroform) to obtain the title compound (9.0 mg, 0.008 mmol, 20%).  $^1\text{H}$  NMR (DMSO- $d_6$ ): 8.98 (m, 1H), 8.58 (m, 1H), 8.23 (m, 1H), 7.81 (m, 1H), 7.21 (m, 1H), 6.41-6.67 (m, 5H), 5.98 (m, 1H), 5.81 (s, 1H), 5.18 (m, 3H), 3.52-3.81 (m, 8H), 3.23 (m, 2H), 2.20-2.81 (m, 6H), 0.83-2.15 (m, 32H). MS,  $[\text{M}+\text{H}]^+ = 1118$ ,  $[\text{M}-\text{H}]^- = 1116$ .

## EXAMPLE 12

### Preparation of Gambogyl-agarose

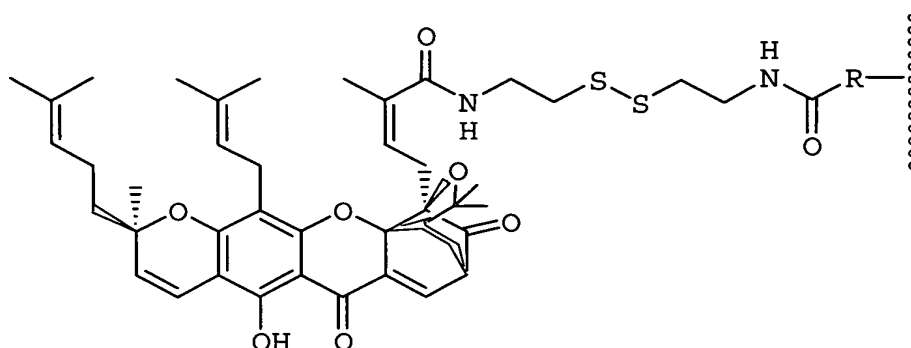


#### Preparation of Gambogyl-agarose:

- [0279] The affi-gel 102 (Amino-agarose, Bio-Rad laboratories, 100 mL, in aqueous) was transferred to a fritted column and washed with DMSO/H<sub>2</sub>O gradient (from 20%, 40%, 60%, 80% DMSO, 250 mL each to 100% DMSO, 500 mL).
- [0280] To the slurry of above agarose (24 mL) in DMSO (20 mL) in the column was added *N*-hydroxysuccinimidyl gambogate (436 mg, 0.60 mmol). The mixture was shaken gently on a shaker for 9 hr at rt. The DMSO was drained and the agarose in the column was washed with DMSO until the washings is colorless (160 mL), then it was washed with 30% aqueous ethanol (200 mL).

### EXAMPLE 13

#### Gambogyl-R-SS-R'-agarose



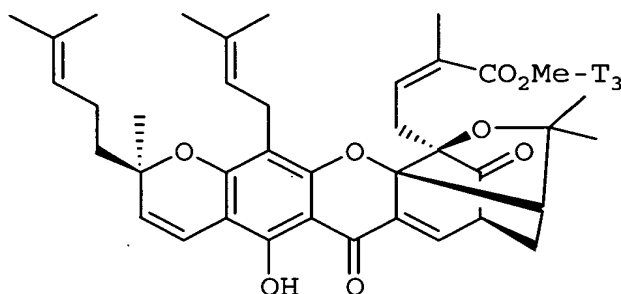
#### Preparation of Gambogyl-R-SS-R'-agarose:

- [0281] The affi-gel 10 (*N*-hydroxysuccinimidyl carboxyl-agarose, Bio-Rad laboratories, in isopropanol) was transferred to a fritted column. The isopropanol was drained and the gel was washed with DMSO (100 mL).
- [0282] To a flask containing cystamine dihydrochloride solution in anhydrous DMSO (20 mL, sonication required) was added Et<sub>3</sub>N (1.04 mL, 7.5 mmol). The solution was added to the above agarose gel column. The flask was washed with anhydrous DMSO (10 mL) and the washing was added the column. The agarose column was mounted on a shaker and shaken gently for 18 hr at rt. The solvent was drained from the column and the column was washed with anhydrous DMSO (150 mL). This converted the *N*-hydroxysuccinimidyl carboxyl-agarose into an amino-R-SS-R'-agarose.
- [0283] A solution of *N*-hydroxysuccinimidyl gambogate (212 mg, 0.292 mmol) in anhydrous DMSO (28 mL) was added to the above amino-R-SS-R'-agarose column. The column was mounted on a shaker and shaken gently for 3 days. The solvent was drained from the column and the gel was washed with

anhydrous DMSO until the washings are colorless (80 mL). The agarose gel column was further washed with 30% aqueous ethanol (200 mL).

#### EXAMPLE 14

##### T<sub>3</sub>-Methyl gambogate



Preparation of methyl gambogate:

[0284] A solution of methyl iodide (29  $\mu$ L, 0.477 mmol) in 1.0 mL of N,N-dimethylformamide was added to a solution of gambogic acid (0.200 g, 0.318 mmol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (47.6  $\mu$ L, 0.318 mmol) in 0.2 mL of N,N-dimethylformamide and the mixture was stirred at room temperature for 3 h. The reaction mixture was poured into brine (30 mL) and was extracted with methylene chloride. The organic layer was wash with brine (2 X 30mL) and the combined organic extracts were dried over MgSO<sub>4</sub> and concentrated in vacuo to give the crude product. It was purified by column chromatography (18 x 2 cm column, SiO<sub>2</sub>, EtOAc/Hexane 1:5) to afford the methyl gambogate as an orange solid (0.14 g, 69 %). <sup>1</sup>H NMR (CDCl<sub>3</sub>): 12.85 (s, 1H), 7.54 (d, *J* = 6.9 Hz, 1H), 6.67 (d, *J* = 10.5 Hz, 1H), 5.94 (t, *J* = 6 Hz, 1H), 5.43 (d, *J* = 10.2 Hz, 1H), 5.05 (m, 2H), 3.49 (m, 1H), 3.43 (s, 3H), 3.35-3.10 (s, 2H), 3.00 (t, *J* = 7.2 Hz, 1H), 2.52 (d, *J* = 10.2 Hz, 1H), 2.32 (quar, *J* = 4.8 Hz, 1H), 2.02 (m, 1H), 1.74 (s, 3H), 1.69 (s, 3H), 1.67-1.64 (m, 9H), 1.55 (s, 3H), 1.44 (s, 3H), 1.29 (s, 3H).

Preparation of T<sub>3</sub>-methyl gambogate:

- [0285] The T<sub>3</sub>-methyl gambogate was prepared similar to methyl gambogate by using radioactive T<sub>3</sub>-MeI instead of MeI. The compound was purified by HPLC. Specific activity: 85 Ci/mmol. Radiochemical purity: 96.8% by HPLC.

#### EXAMPLE 15

##### 3,4-dihydroxyxanthen-9-one

- [0286] To a stirring solution of 2-fluorobenzoic acid (5.09 g, 36.3 mmol) and dichloromethane (110 mL) in an ice bath under argon was added dropwise a solution of oxalyl chloride (2.0 M in dichloromethane, 21 mL, 42 mmol), followed by dimethylformamide (6 drops). The ice bath was removed and the solution was stirred at room temperature for 1.5 h. The solution was then concentrated by rotary evaporation. The product was dissolved in hexane (3 x 50 mL) and the mixture was filtered. The filtrate was rotary evaporated to yield 5.42 g of colorless oil. The oil was added dropwise to a mixture of pyrogallol (6.48 g, 51.3 mmol), aluminum chloride (14.6 g, 110 mmol), chloroform (250 mL) and dichloromethane (700 mL), and the solution was stirred for 17 h at room temperature. The solution was then refluxed for 3 h and cooled to room temperature. The solution was washed with 1 N HCl (3 x 500 mL). The organic layer was filtered, dried over sodium sulfate, and evaporated to yield an oil. The oil was added to dimethylformamide (120 mL) with sodium carbonate (8.11 g, 76.5 mmol) and it was refluxed for 3.5 h. The solution was concentrated by rotary evaporation with heating, and the residue was purified by column chromatography (95:5 chloroform / methanol) to give a solid. The solid was washed with hexane (2 x 35 mL), filtered and dried to yield 2.10 g (25 %) of the title compound as an off-white solid. <sup>1</sup>H NMR

(DMSO- $d_6$ , 300 MHz):  $\delta$  8.16 (d,  $J$  = 7.42 Hz, 1H), 7.84 (t,  $J$  = 7.69 Hz, 1H), 7.64 (d,  $J$  = 8.52 Hz, 1H), 7.57 (d,  $J$  = 8.79 Hz, 1H), 7.44 (t,  $J$  = 7.41 Hz, 1H), 6.94 (d,  $J$  = 8.52 Hz, 1H).

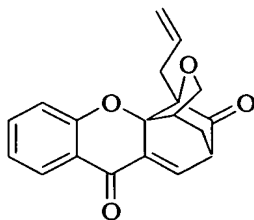
#### EXAMPLE 16

##### 3,4-bis-allyloxyxanthen-9-one

[0287] A stirred solution of 3,4-dihydroxyxanthen-9-one (290 mg, 1.27 mmol), allyl bromide (800  $\mu$ L, 9.20 mmol), potassium carbonate hydrate (1.28 g, 7.77 mmol) and acetone (15.0 mL) was refluxed for 2.5 h. The solution was cooled to room temperature and dichloromethane was added. The mixture was filtered and the filtrate was rotary evaporated to yield 372 mg (95%) of the title compound as a white solid.  $^1\text{H}$  NMR (DMSO- $d_6$ , 300 MHz):  $\delta$  8.33 (dd,  $J_1$  = 7.84 Hz,  $J_2$  = 1.79, 1H), 8.07 (d,  $J$  = 8.79 Hz, 1H), 7.72 (ddd,  $J_1$  = 8.10 Hz,  $J_2$  = 7.01,  $J_3$  = 1.65, 1H), 7.56 (dd,  $J_1$  = 8.51 Hz,  $J_2$  = 0.55, 1H), 7.38 (ddd,  $J_1$  = 7.76 Hz,  $J_2$  = 7.07,  $J_3$  = 1.03, 1H), 7.00 (d,  $J$  = 9.06 Hz, 1H), 6.15 (m, 2H), 5.48 (m, 1H), 5.38 (m, 2H), 5.25 (m, 1H), 4.74 (m, 4H).

#### EXAMPLE 17

##### 1-Allyl-1,3,3a,4,5,12a-hexahydro-7,13-dioxo-1,5-methano-furo[3,4-*d*]xanthene

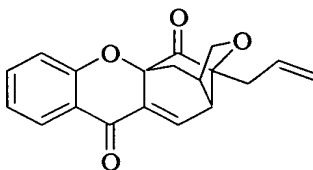


[0288] A stirred solution of 3,4-bis-allyloxy-xanthen-9-one (236.4 mg, 0.767 mmol) and diphenyl ether (3.0 mL) was refluxed in an oil bath at 190  $^{\circ}\text{C}$  for 11 h. The solution was cooled to room temperature and product was purified

twice by flash column chromatography (dichloromethane) to yield 28.0 mg (12 %) of the title compound as a white solid.  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz):  $\delta$  7.95 (dd,  $J_1 = 7.69$  Hz,  $J_2 = 1.65$ , 1H), 7.56 (ddd,  $J_1 = 8.17$  Hz,  $J_2 = 7.07$ ,  $J_3 = 1.58$ , 1H), 7.34 (d,  $J = 7.14$  Hz, 1H), 7.08 (m, 1H), 5.22 (m, 1H), 4.69 (m, 1H), 4.53 (m, 1H), 3.91 (d,  $J = 7.97$  Hz, 1H), 3.53 (ddd,  $J_1 = 6.11$  Hz,  $J_2 = 3.43$ ,  $J_3 = 2.06$ , 1H), 2.82 (dd,  $J_1 = 13.33$  Hz,  $J_2 = 5.35$ , 1H), 2.63 (m, 1H), 2.51 (dd,  $J_1 = 13.60$  Hz,  $J_2 = 9.48$ , 1H), 1.90 (m, 1H), 1.78 (ddd,  $J_1 = 12.22$  Hz,  $J_2 = 10.38$ ,  $J_3 = 2.39$ , 1H).

#### EXAMPLE 18

1-Allyl-1,3,3a,4,4a,11a-hexahydro-10,12-dioxo-1,4a-methano-furo[3,4-*b*]xanthene

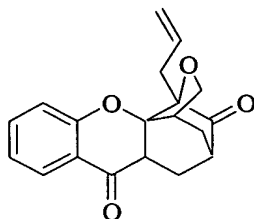


[0289] The procedure in example 3 also yielded 44.5 mg (19%) of the title compound as a white solid.  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz):  $\delta$  7.93 (dd,  $J_1 = 7.96$  Hz,  $J_2 = 1.92$ , 1H), 7.56 (ddd,  $J_1 = 8.24$  Hz,  $J_2 = 7.01$ ,  $J_3 = 1.78$ , 1H), 7.31 (d,  $J = 6.87$  Hz, 1H), 7.19 (dd,  $J_1 = 8.38$  Hz,  $J_2 = 0.96$ , 1H), 7.08 (m, 1H), 5.60 (m, 1H), 5.15 (s, 1H), 5.11 (m, 1H), 4.09 (dd,  $J_1 = 8.25$  Hz,  $J_2 = 3.57$ , 1H), 3.97 (d,  $J = 8.24$  Hz, 1H), 3.48 (dd,  $J_1 = 6.87$  Hz,  $J_2 = 4.39$ , 1H), 2.63 (dd,  $J_1 = 14.28$  Hz,  $J_2 = 6.59$ , 1H), 2.55 (m, 1H), 2.29 (dd,  $J_1 = 12.50$  Hz,  $J_2 = 5.90$ , 1H), 2.23 (d,  $J = 5.77$  Hz, 1H).



EXAMPLE 19

1-allyl-1,3,3a,4,5,6,6a,12a-octahydro-7,13-dioxo-1,5-methano-furo[3,4-*d*]xanthene



[0290] To a stirring solution of 1-allyl-1,3,3a,4,5,12a-hexahydro-7,13-dioxo-1,5-methano-furo[3,4-*d*]xanthene (29.0 mg, 0.0941 mmol) and tetrahydrofuran (15.0 mL) in a dry ice bath under argon was added dropwise 1.0 M L-Selectride in THF (150  $\mu$ L, 0.150 mmol) and the solution was stirred for 25 min. The dry ice bath was removed and the solution was stirred for 20 minutes. The solution was concentrated by rotary evaporation and was purified by column chromatography (2:1 hexanes / ethyl acetate) to yield 11.4 mg (39%) of the title compound as a white solid.  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz):  $\delta$  7.91 (dd,  $J_1 = 8.11$  Hz,  $J_2 = 1.79$ , 1H), 7.54 (ddd,  $J_1 = 8.17$  Hz,  $J_2 = 6.94$ ,  $J_3 = 1.45$ , 1H), 7.08 (m, 2H), 5.86 (m, 1H), 5.27 (m, 1H), 5.12 (dt,  $J_1 = 10.16$  Hz,  $J_2 = 1.51$ , 1H), 4.16 (dd,  $J_1 = 7.97$  Hz,  $J_2 = 4.12$ , 1H), 3.53 (d,  $J = 7.96$  Hz, 1H), 3.40 (dd,  $J_1 = 11.54$  Hz,  $J_2 = 3.30$ , 1H), 3.06 (dd,  $J_1 = 13.46$  Hz,  $J_2 = 6.04$ , 1H), 2.87 (dd,  $J_1 = 13.32$  Hz,  $J_2 = 8.93$ , 1H), 2.82 (dt,  $J_1 = 14.28$  Hz,  $J_2 = 3.57$ , 1H), 2.74 (dd,  $J_1 = 9.89$  Hz,  $J_2 = 4.39$ , 1H), 2.44 (m, 1H), 2.01 (dd,  $J_1 = 13.47$  Hz,  $J_2 = 10.44$ , 1H), 1.78 (ddt,  $J_1 = 14.15$  Hz,  $J_2 = 11.67$ ,  $J_3 = 2.68$ , 1H), 1.67 (dt,  $J_1 = 14.10$  Hz,  $J_2 = 3.50$ , 1H).

## EXAMPLE 20

### 3,4-Bis-(1,1-dimethyl-prop-2-ynyloxy)-xanthen-9-one

[0291] A solution of 3,4-dihydroxy-xanthen-9-one (1.25 g, 5.47 mmol), cupric chloride (30.2 mg, 0.225), 3-chloro-3-methyl-1-butyne (3.36 mL, 29.9 mmol), 1,8-diazabicyclo[5.4.0]undec-7-ene (2.00 mL, 13.3 mmol), and acetonitrile (100 mL) was stirred at room temperature for 11 h under argon. The solution was then heated at 75 °C for 2 h and cooled to room temperature. The solution was partitioned between ethyl acetate (100 mL) and water (75 mL). The ethyl acetate layer was dried over sodium sulfate and was concentrated by rotary evaporation. The product was purified by flash column chromatography (10:1 hexanes/ethyl acetate) to yield 496 mg (25%) of the title compound as a light yellow solid. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz): δ 8.33 (dd, *J*<sub>1</sub> = 7.97 Hz, *J*<sub>2</sub> = 1.65, 1H), 8.07 (d, *J* = 9.06 Hz, 1H), 7.71 (ddd, *J*<sub>1</sub> = 8.18 Hz, *J*<sub>2</sub> = 7.08, *J*<sub>3</sub> = 1.58, 1H), 7.65 (d, *J* = 9.06 Hz, 1H), 7.52 (dd, *J*<sub>1</sub> = 8.52 Hz, *J*<sub>2</sub> = 0.55, 1H), 7.38 (m, 1H), 2.66 (s, 1H), 2.30 (s, 1H), 1.84 (s, 6H), 1.77 (s, 6H).

## EXAMPLE 21

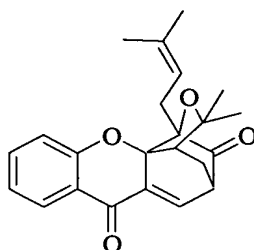
### 3,4-Bis-(1,1-dimethyl-allyloxy)-xanthen-9-one

[0292] To a solution of 3,4-bis-(1,1-dimethyl-prop-2-ynyloxy)-xanthen-9-one (318 mg, 0.882 mmol) in methanol (25 mL) was added Lindlar's catalyst (Pd, 5 wt % on calcium carbonate, 75 mg) under hydrogen (1 atm). The mixture was stirred at room temperature for 1 h, then the mixture was filtered through a syringe filter and the solvent was evaporated. The residue was purified by column chromatography (SiO<sub>2</sub>, EtOAc:hexanes/10-25%) to give the product as a white solid (249 mg, 77%): <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 8.31 (dd, *J* = 1.8, 8.1 Hz, 1H), 7.93 (d, *J* = 9.0 Hz, 1H), 7.70 (m, 1H), 7.50 (dd, *J* = 0.9, 8.7 Hz, 1H), 7.37 (m, 1H), 7.13 (d, *J* = 9.0 Hz, 1H), 6.30 (dd, *J* = 10.8, 17.7 Hz,

1H), 6.20 (dd, J = 11.1, 17.1 Hz, 1H), 5.25-5.16 (m, 3H), 5.03 (dd, J = 0.9, 10.5 Hz, 1H), 1.59 (s, 3H), 1.58 (s, 3H).

#### EXAMPLE 22

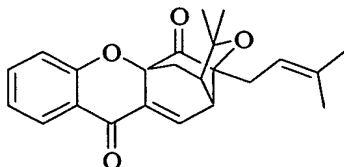
1-(3-Methyl-2-butenyl)-3,3-dimethyl-1,3,3a,4,5,12a-hexahydro-7,13-dioxo-1,5-methano-furo[3,4-d]xanthene



[0293] A solution of 3,4-bis-(1,1-dimethyl-allyloxy)-xanthen-9-one (229 mg, 0.587 mmol) in toluene (10 mL) was refluxed under argon for 2 h. The solvent was evaporated and the residue was purified by column chromatography (SiO<sub>2</sub>, EtOAc:hexanes/10-30%) to give the title compound as white solids (145 mg, 63%): <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 7.95 (dd, J = 1.5, 7.8 Hz, 1H), 7.53 (ddd, J = 1.5, 7.2, 8.1 Hz, 1H), 7.44 (dd, J = 0.6, 7.2 Hz, 1H), 7.07 (m, 2H), 4.42 (m, 1H), 3.50 (dd, J = 4.5, 6.9 Hz, 1H), 2.63 (m, 2H), 2.46 (d, J = 9.3 Hz, 1H), 2.35 (dd, J = 4.2, 12.6 Hz, 1H), 1.73 (s, 3H), 1.31 (m, 1H), 1.31 (s, 6H), 0.92 (s, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 75 MHz) δ 202.8, 176.3, 159.5, 136.1, 134.8, 134.7, 133.6, 126.8, 121.8, 119.0, 118.9, 118.0, 90.3, 84.6, 83.5, 48.8, 46.8, 30.4, 29.2, 25.4, 25.2, 16.8.

#### EXAMPLE 23

1-(3-Methyl-2-butenyl)-3,3-dimethyl-1,3,3a,4,4a,11a-hexahydro-10,12-dioxo-1,4a-methano-furo[3,4-b]xanthene



[0294] The procedure in example 8 also yielded 18 mg (8%) of the title compound as a white solid. <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 7.92 (dd, J = 1.8, 8.1 Hz, 1H), 7.55 (ddd, J = 1.8, 7.2, 8.7 Hz, 1H), 7.26 (d, J = 6.9 Hz, 1H), 7.20 (dd, J = 0.6, 8.4 Hz, 1H), 7.07 (dd, J = 1.2, 7.2 Hz, 1H), 5.03 (m, 1H), 3.77 (dd, J = 4.5, 6.9 Hz, 1H), 2.56 (d, J = 13.2 Hz, 1H), 2.50 (dd, J = 6.9, 15.3 Hz, 1H), 2.17 (dd, J = 4.5, 9.6 Hz, 1H), 2.09 (dd, J = 8.4, 14.7 Hz, 1H), 1.88 (dd, J = 9.9, 13.2 Hz, 1H), 1.72 (s, 3H), 1.60 (s, 3H), 1.39 (s, 3H), 1.35 (s, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 75 MHz) δ 199.7, 175.4, 160.2, 136.5, 136.1, 135.9, 134.9, 127.0, 122.0, 119.2, 118.3, 117.3, 84.1, 83.7, 78.8, 44.8, 42.1, 33.1, 30.2, 29.7, 26.8, 26.0, 18.2.

#### EXAMPLE 24

##### 3,4-Bis-allyloxy-benzophenone

[0295] To a suspension of 3,4-dihydroxybenzophenone (2.140 g, 10 mmol) and cesium carbonate (7.010 g, 21.6 mmol) in dry acetone (50 mL) was added allylbromide (5.3 mL, 60 mmol). The mixture was stirred at 60°C for 6 h and additional allylbromide (3.0 mL, 34.7 mmol) and cesium carbonate (3.000 g, 9.2 mmol) were added. The mixture was stirred for 3 h, cooled to room temperature, filtered and washed with EtOAc. The filtrate and washing were combined and evaporated under reduced pressure. The crude product was partitioned between EtOAc (50 mL) and H<sub>2</sub>O (15 mL). The EtOAc phase was separated and evaporated to give a light yellow oil (2.922 g, 99%): <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 7.77 (m, 1H), 7.74 (m, 1H), 7.57 (m, 1H), 7.50-7.44 (m, 3H), 7.38 (ddd, J = 0.9, 2.4, 8.7 Hz, 1H), 6.91 (d, J = 8.4 Hz, 1H), 6.08 (m, 2H), 5.47 (m, 1H), 5.41 (m, 1H), 5.32 (m, 2H), 4.68 (m, 4H).

## EXAMPLE 25

### (2,5-Diallyl-3,4-dihydroxy)-benzophenone

[0296] A solution of 3,4-bis-allyloxy-benzophenone (1.510 g, 5.1 mmol) in diphenyl ether (3 mL) was stirred at 200°C for 2 h. The reaction mixture was cooled and the mixture was purified by column chromatography (SiO<sub>2</sub>, 30 % EtOAc in hexanes) to give a light yellow oil (0.840 g, 56%): <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 7.79 (m, 2H), 7.57 (m, 1H), 7.44 (t, J = 7.8 Hz, 2H), 6.78 (s, 1H), 6.16-5.86 (m, 3H), 5.60 (brs, 1H), 5.12 (m, 4H), 3.51 (d, J = 6.0 Hz, 2H), 3.39 (d, J = 6.6 Hz, 2H).

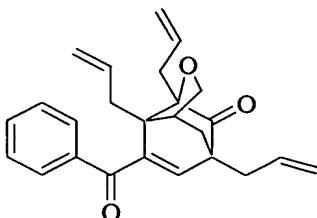
## EXAMPLE 26

### (2,5-Diallyl-3,4-bis-allyloxy)-benzophenone

[0297] A suspension of (2,5-diallyl-3,4-dihydroxy)-benzophenone (840 mg, 2.85 mmol), cesium carbonate (2.780 g, 8.55 mmol) and allylbromide (1.5 mL, 17.3 mmol) was stirred at 60°C for 20 h. The mixture was filtered and washed with EtOAc. The filtrate was evaporated and the crude product was purified by column chromatography (SiO<sub>2</sub>, 10-30 % EtOAc:hexanes) to give a light yellow oil (880 mg, 83%): <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 7.81-7.77 (m, 2H), 7.57 (tt, J = 1.5, 7.2 Hz, 1H), 7.47-7.41 (m, 2H), 6.90 (s, 1H), 6.10 (m, 2H), 5.89 (m, 2H), 5.43 (m, 1H), 5.38 (m, 1H), 5.27 (m, 1H), 5.24 (m, 1H), 5.04 (m, 1H), 5.00 (m, 1H), 4.88 (m, 1H), 4.83 (dq, J = 10.2, 1.5 Hz, 1H), 4.57-4.51 (m, 4H), 3.50 (dt, J = 6.3, 1.5 Hz, 2H), 3.89 (dt, J = 6.6, 1.2 Hz, 2H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 75 MHz) δ 197.4, 151.6, 150.5, 137.7, 136.9, 136.5, 134.9, 133.8, 133.8, 132.9, 132.1, 131.8, 130.2, 128.2, 125.8, 117.6, 117.4, 115.9, 115.3, 73.7, 73.7, 34.0, 31.0.

### EXAMPLE 27

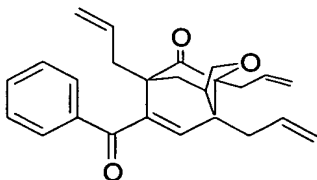
1,3,7-Triallyl-8-benzoyl-4-oxa-tricyclo[4.3.1.0<sup>3,7</sup>]dec-8-en-2-one



[0298] A solution of (2,5-diallyl-3,4-bis-allyloxy)benzophenone (474 mg, 1.27 mmol) in diphenyl ether (3 mL) was stirred at 200°C for 2 h. The reaction mixture was cooled to room temperature and the product was purified by column chromatography (SiO<sub>2</sub>, CH<sub>2</sub>Cl<sub>2</sub>) to give the title compound (190 mg, 35%). <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 7.80-7.75 (m, 2H), 7.59 (m, 1H), 7.48-7.43 (m, 2H), 6.23(s, 1H), 5.85-5.58 (m, 2H), 5.36 (m, 1H), 5.21-5.06 (m, 3H), 5.02-.591 (m, 3H), 4.14(dd, J = 4.5, 8.7 Hz, 1H), 3.72 (d, J = 8.4 Hz, 1H), 3.01 (dd, J = 5.7, 13.8 Hz, 1H), 2.93 (dd, J = 7.2, 14.4 Hz, 1H), 2.66-2.51 (m, 3H), 2.41-2.29 (m, 2H), 2.08 (dd, J = 10.2, 13.2 Hz, 1H), 1.70 (d, J = 13.5 Hz, 1H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 75 MHz) δ 204.4, 192.8, 141.6, 139.8, 136.5, 133.8, 133.2, 132.5, 132.0, 129.7, 128.3, 119.3, 118.8, 118.5, 83.5, 53.4, 51.1, 50.9, 39.6, 39.3, 34.3, 33.5, 32.7.

### EXAMPLE 28

1,3,7-Triallyl-9-benzoyl-4-oxa-tricyclo[4.3.1.0<sup>3,7</sup>]dec-8-en-2-one



[0299] The procedure in example 13 also yielded the title compound (79 mg, 14%). <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 7.79-7.76 (m, 2H), 7.60 (tt, J = 1.5, 6.6 Hz, 1H), 7.50-7.44 (m, 2H), 6.33 (s, 1H), 5.98-5.73 (m, 2H), 5.60 (m, 1H), 5.16-4.95 (m, 6H), 4.18 (dd, J = 4.5, 8.4 Hz, 1H), 3.70 (d, J = 8.7 Hz, 1H),

3.49 (m, 1H), 2.81 (dd,  $J = 14.4, 8.7$  Hz, 1H), 2.67 (dd,  $J = 4.5$  Hz, 9.9 Hz, 1H), 2.56-2.50 (m, 2H), 2.45-2.37 (m, 1H), 2.24 (dd,  $J = 9.3, 14.7$  Hz, 1H), 2.02 (dd,  $J = 10.2, 12.9$  Hz, 1H), 1.69 (d,  $J = 13.8$ , 1H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 75 MHz)  $\delta$  205.5, 193.8, 141.2, 141.1, 137.3, 133.7, 133.3, 132.9, 132.0, 129.9, 128.3, 118.9, 118.7, 118.3, 82.7, 74.3, 53.2, 49.5, 39.7, 38.5, 35.3, 34.0, 30.6.

### EXAMPLE 29

#### 7,8-Bis-(1,1-dimethyl-prop-2-ynyloxy)-2-phenyl-chromen-4-one

[0300] To a suspension of 7,8-dihydroxy-2-phenyl-chromen-4-one (510 mg, 2 mmol) and  $\text{CuCl}_2$  (16 mg, 0.12 mmol) in acetonitrile (3 mL) was added 3-chloro-3-methyl-1-butyne (0.5 mL, 4.56 mmol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (0.78 mL, 5.2 mmol) slowly at 0 °C. The dark mixture was stirred at 0 °C for 5 h and then at room temperature overnight. The solvent was evaporated and the residue was purified by column chromatography ( $\text{SiO}_2$ , EtOAc:hexanes/10-50%) to give the title compound as a white solid (540 mg, 69%):  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz)  $\delta$  8.02 (m, 2H), 7.96 (d,  $J = 9.0$  Hz, 1H), 7.69 (d,  $J = 9.0$  Hz, 1H), 7.53 (m, 3H), 6.78 (s, 1H), 2.66 (s, 1H), 2.26 (s, 1H), 1.81 (s, 6H), 1.76 (s, 6H).

### EXAMPLE 30

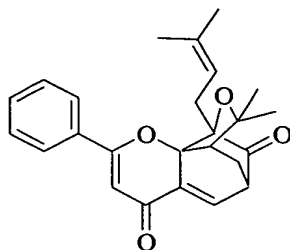
#### 7,8-Bis-(1,1-dimethyl-allyloxy)-2-phenyl-chromen-4-one

To a solution of 7,8-bis-(1,1-dimethyl-prop-2-ynyloxy)-2-phenyl-chromen-4-one (98 mg, 0.254 mmol) in methanol (20 mL) was added Lindlar's catalyst (Pd, 5 wt % on calcium carbonate, 25 mg) under argon. The mixture was stirred at room temperature for 50 min, then it was filtered through a syringe filter and the solvent was evaporated. The residue was purified by column chromatography ( $\text{SiO}_2$ , EtOAc:hexanes/10-25%) to give the product as a white solid (72 mg, 73%):  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz)  $\delta$  7.98 (m, 2H), 7.81 (dd,  $J = 0.9, 9.0$  Hz, 1H), 7.52 (m, 3H), 7.16 (dd,  $J = 0.6, 9.0$  Hz,

1H), 6.75 (d, J = 0.6 Hz, 1H), 6.22 (m, 2H), 5.24-5.12 (m, 3H), 4.98 (dd, J = 1.2, 10.2 Hz, 1H), 1.56 (s, 6H), 1.55 (s, 6H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 75 MHz) δ 178.1, 163.0, 154.9, 152.5, 136.0, 132.0, 131.2, 128.8, 126.6, 120.5, 119.6, 117.5, 107.3, 85.2, 74.9, 74.1, 73.9, 30.7, 29.8.

### EXAMPLE 31

1-(3-Methyl-2-butenyl)-3,3-dimethyl-1,3,3a,4,5,10a-hexahydro-7,11-dioxo-9-phenyl-1,5-methano-furo[3,4-i]chromene

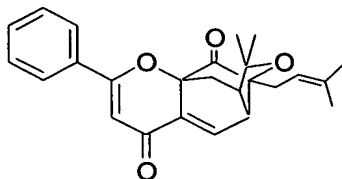


[0301] A solution of 7,8-bis-(1,1-dimethyl-allyloxy)-2-phenyl-chromen-4-one in diphenyl ether (2 mL) was stirred at 120°C under argon for three h. The reaction mixture was cooled to room temperature and the product was purified by column chromatography (SiO<sub>2</sub>, EtOAc:hexanes/10-30%) to give the title compound (45 mg, 52%): <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz) δ 7.85-7.82 (m, 2H), 7.57-7.46 (m, 3H), 7.30 (d, J = 6.9 Hz, 1H), 6.13 (s, 1H), 4.69 (m, 1H), 3.48 (dd, J = 4.5, 6.9 Hz, 1H), 2.67-2.56 (m, 2H), 2.52 (d, J = 9.3 Hz, 1H), 2.34 (dd, J = 4.5 Hz, 13.5 Hz, 1H), 1.69 (s, 3H), 1.40 (s, 3H), 1.31 (s, 3H), 1.36 (m, 1H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 75 MHz) δ 203.0, 177.1, 168.4, 134.5, 134.1, 132.9, 131.7, 131.2, 128.8, 126.5, 117.9, 100.8, 92.7, 84.3, 83.2, 49.2, 46.5, 30.4, 29.1, 29.0, 25.7, 25.0, 17.8.



### EXAMPLE 32

1-(3-Methyl-2-butenyl)-3,3-dimethyl-1,3,3a,4,4a,9a-hexahydro-8,10-dioxo-6-phenyl-1,4a-methano-furo[3,4-g]chromene



[0302] The procedure in example 17 also yielded the title compound (21 mg, 24%):  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz)  $\delta$  7.91-7.87 (m, 2H), 7.55-7.43 (m, 3H), 7.06 (d,  $J$  = 6.6 Hz, 1H), 6.09 (s, 1H), 5.07 (m, 1H), 3.77 (dd,  $J$  = 4.5, 6.9 Hz, 1H), 2.59 (d,  $J$  = 13.2 Hz, 1H), 2.53 (dd,  $J$  = 6.6, 15.3 Hz, 1H), 2.16 (dd,  $J$  = 4.2, 9.3 Hz, 1H), 2.11 (dd,  $J$  = 8.7, 15.0 Hz, 1H), 1.91 (dd,  $J$  = 9.9, 13.2 Hz, 1H), 1.74 (s, 3H), 1.61 (s, 3H), 1.40 (s, 3H), 1.36 (s, 3H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 75 MHz)  $\delta$  198.7, 175.9, 169.6, 136.1, 135.3, 132.8, 131.8, 131.1, 128.6, 126.8, 117.2, 101.3, 86.0, 83.7, 78.7, 44.5, 41.6, 32.8, 30.2, 29.6, 26.8, 26.0, 18.3.

### EXAMPLE 33

#### Isolation and Identification of Transferrin Receptor

Isolation of transferrin receptor from intact cells using FITC-tagged gambogic acid:

[0303] Jurkat cells were grown in RPMI 1640 media containing 25 mM Hepes and L-glutamine (Gibco) supplemented with 10 % FCS and penicillin/streptomycin and harvested by centrifugation (200 x g, 10 minutes) when they reached a concentration of  $1 \times 10^6$  cells/mL.  $1 \times 10^9$  Jurkat cells were resuspended in 100 mL RPMI 1640 media with 0.5 % FCS. Cells were then treated with either 1 % DMSO or 5  $\mu\text{M}$  5-[(5-gambogylaminopentyl)-

thioureidyl]-fluorescein (Example 10) in DMSO for 30 minutes at 37 °C. Cells were washed one time with 40 mL phosphate buffered saline (PBS) and lysed in 8 mL RIPA buffer (10x RIPA supplied by Upstate) and 0.1% Protease Inhibitor Cocktail (Sigma). The lysed cells were spun at 20,000 x g for 10 minutes and the supernatant collected and referred to as "Jurkat lysate."

Protein concentration of the lysate was determined by DC Assay (BioRad).

[0304] 30 mg of Jurkat lysate was mixed with 100 µL Protein A Sepharose beads (Zymed) which had been washed 2 times with 1 mL PBS and incubated at 4 °C for 2 hours. The mix was centrifuged 1 minute at 2,700 x g. The supernatant was removed from the Protein A Sepharose beads and 50 µg of rabbit anti-FITC antibody (Zymed) was added. Lysates and antibody were incubated with gentle rocking at 4 °C for 2 hours. 100 µL pre-washed Protein A Sepharose beads were added to the mix and further incubated overnight, with gentle rocking at 4 °C. The Sepharose beads were collected by centrifugation (2,700 x g, 1 minute) and washed 6 times with 1 mL of PBS + 0.2 % NP-40. 100 µL of 2x SDS sample buffer (Invitrogen Corporation) with 40 mM dithiothreitol (DTT) was added to the beads and the beads were boiled at 100 °C for 5 minutes. Samples were spun down at 20,000 x g for 1 minute and the supernatant removed and loaded onto 6 mm wide wells on a 16 cm x 20 cm x 1 mm 4 % SDS polyacrylamide gel in Tris-glycine running buffer (Invitrogen Corporation) and run at 35 mA for 4 hours at room temperature. The gel was removed from the glass plate and stained with 1 % coomassie blue in 40 % methanol, 7.5 % acetic acid overnight at room temperature. The gel was destained in a solution of 40 % methanol, 7.5 % acetic acid with several changes of solution until protein bands were visible. Stained bands were excised with a clean razor blade and stored in microfuge tubes for tryptic digest.

Trypsin digestion:

[0305] The gel slice was further destained in 30 % MeOH until the background was nearly clear. The gel slice was incubated for at least an hour in 500  $\mu$ L of 100 mM ammonium bicarbonate. Then 150  $\mu$ L of 100 mM ammonium bicarbonate and 10  $\mu$ L of 45mM DTT were added and incubated at 60 °C for 30 minutes. Samples were cooled to room temperature and 10  $\mu$ L of 100 mM iodoacetamide was added and the sample was incubated for 30 minutes in the dark at room temperature. The solution was removed and discarded and 500  $\mu$ L of 50 % acetonitrile and 50 % 100 mM ammonium bicarbonate, pH 8.9, was added and the sample was incubated with shaking for 1 hour at room temperature. The gel was removed, cut into 2-3 pieces and transferred to a 200  $\mu$ L Eppendorf tube. 50 $\mu$ L acetonitrile was added for 10-15 minutes and then removed. The gel slices were dried in a Savant rotatory evaporator. The gel pieces were incubated with 10  $\mu$ L of 25mM ammonium bicarbonate containing Promega modified trypsin (sequencing grade) at a concentration such that a substrate to enzyme ratio of 10:1 was achieved (typically 0.1  $\mu$ g). The protein amounts are estimated from the staining intensity of the gel. After 10-15 minutes 10-20  $\mu$ L 25 mM ammonium bicarbonate was added to cover the gel pieces and incubated overnight at 37 °C. The samples were then frozen at -20 °C until analysis by molecular mass sequencing.

LC-MS/MS peptide sequencing and protein identification:

[0306] This was carried out by standard procedures at a mass spectrometry sequencing facilities: Mass Consortium, San Diego, CA or Centre Proteomique de l'Est du Québec, Ste-Foy, Quebec, Canada or equivalent facilities. In short, the samples were run on LC-MS/MS ion trap instruments and the parent and fragments were analyzed for mass to charge ratios. From the degradation fragments, a peptide sequence was deduced which is generally within 1 amu of the predicted mass. These sequences were then compared to

peptide sequences in gene sequence or protein sequence databases. Identity of peptide sequence with predicted tryptic fragments from gene sequences indicates the peptide as part of the gene. The size of the peptide matched and/or the number of matched peptides confirmed the identity of the protein.

[0307] The following lists the experimentally deduced peptide sequence having the closest fitting calculated molecular weight.

[0308] An NCBI Blast search (accessible at <http://www.ncbi.nlm.nih.gov/BLAST/>) using this peptide revealed that it is a part of SEQ ID NO: 1 or 4.

<u>Sequence</u>	<u>aa Positions</u>
VSASPLLYTLIEK	amino acids 496-508 of SEQ ID NO. : 1 or 4

#### EXAMPLE 34

##### Isolation and Identification of Transferrin Receptor

Isolation of transferrin receptor from plasma membrane fraction of Jurkat cells by gambogyl affinity chromatography:

[0309] Jurkat cells were grown in RPMI 1640 media containing 25 mM Hepes and L-glutamine (Gibco) supplemented with 10 % FCS and penicillin/streptomycin and harvested by centrifugation (200 x g, 10 minutes) when they reached a concentration of  $1 \times 10^6$  cells/mL.  $5 \times 10^9$  Jurkat cells were resuspended gently in 4 mL of 10 mM Tris, pH 7.5, with 4  $\mu$ L of Protease Inhibitor Cocktail (P3840, Sigma) and incubated on ice for 10 minutes. Cells were homogenized with a Dounce homogenizer and type A pestle for five minutes on ice. Cell lysates were stored in microfuge tubes and frozen.

[0310] For plasma membrane isolation, 2 mL of lysate was placed into an ultracentrifuge tube (Ultraclear, 15 mL tube, for Beckman rotor JS24.15)

along with 2 mL of 60 % sucrose, 10 mM Tris, pH 7.5, and mixed. 7 mL of 20 % sucrose, 10 mM Tris, pH 7.5, solution was carefully layered onto the lysate and the meniscus marked. 4 ml of a 10 % sucrose, 10 mM Tris, pH 7.5, solution was carefully layered on. The tubes were spun at 22,000 rpm (93,000 x g) for 2 hours at 4 °C. The membrane fraction which is seen at the 10 % and 20 % sucrose interface (indicated by the meniscus mark) was carefully removed (approximately 3 mL) with a syringe and needle by side puncture of the tube. The membrane fraction was put into a new ultracentrifuge tube, 12 mL of 10 mM Tris, pH 7.5, 140 mM NaCl was added, the solution mixed by inverting the covered tube, and centrifuged at 22,000 rpm for 1 hour at 4 °C. The supernatant liquid was removed down close to the cloudy white pellet and a Pasteur pipette was used to remove the remaining liquid. Tubes were turned upside down on a paper towel to drain. The membrane pellet was resuspended in 50 µL of PBS with 1 % CHAPS, placed in a microfuge tube and frozen. Protein concentration was determined by DC protein assay (BioRad).

[0311] 50 µg of membrane protein (approximately 100 µL) was brought up to 500 µL with RIPA buffer (InVitrogen) and clarified by centrifugation, 60,000 x g, 15 minutes, 4 °C. The supernatant was removed and incubated with gambogyl-R-SS-R'-agarose (Example 13), 60 µL, for 45 minutes at room temperature with gently mixing. (Gambogyl-R-SS-R'-agarose was washed 2 times with 1 mL RIPA buffer prior to use). The beads were collected by centrifugation (2,700 x g, 1 minute). Beads were washed 2 times with RIPA buffer and then 2 times with RIPA buffer adjusted to 350 mM NaCl. Washes were done at room temperature, 5 minutes each, and the beads were collected by centrifugation (2,700xg 1 minute). 20 µL RIPA buffer and 80 µL 2x SDS sample buffer (InVitrogen) with 40 mM DTT was added to the beads and boiled for 5 min. The beads were spun down by centrifugation and the supernatant was removed and loaded onto 6 mm wide 6 % SDS polyacrylamide gels (16 cm x 20 cm x 1 mm) in Tris-glycine running buffer (Invitrogen Corporation) at 35 mA for 4 hours at room temperature.

**[0312]** Proteins are resolved by electrophoresis on a 6 % polyacrylamide gel. The gel was removed from the glass plate and stained with 1 % coomassie blue in 40 % methanol, 7.5 % acetic acid overnight at room temperature. The gel was destained in a solution of 40 % methanol, 7.5 % acetic acid with several changes of solution until protein bands are visible. Stained bands were excised with a clean razor blade and stored in a microfuge tube for tryptic digestion.

Trypsin digestion:

**[0313]** The gel slice was further destained in 30 % MeOH until the background was nearly clear. The gel slice was incubated for at least an hour in 500  $\mu$ L of 100 mM ammonium bicarbonate. Then 150  $\mu$ L of 100 mM ammonium bicarbonate and 10  $\mu$ L of 45mM DTT was added and incubated at 60 °C for 30 minutes. Samples were cooled to room temperature and 10  $\mu$ L of 100 mM iodoacetamide was added and the sample incubated for 30 minutes in the dark at room temperature. The solution was removed and discarded and 500  $\mu$ L of 50 % acetonitrile and 50 % 100 mM ammonium bicarbonate, pH 8.9, was added and the sample was incubated with shaking for 1 hour at room temperature. The gel was removed, cut into 2-3 pieces and transferred to a 200  $\mu$ L Eppendorf tube. 50 $\mu$ L acetonitrile was added for 10-15 minutes and then removed. The gel slices were dried in a Savant rotatory evaporator. The gel pieces were incubated with 10  $\mu$ L of 25mM ammonium bicarbonate containing Promega modified trypsin (sequencing grade) at a concentration such that a substrate to enzyme ratio of 10:1 had been achieved (typically 0.1  $\mu$ g). The protein amounts are estimated from the staining intensity of the gel. After 10-15 minutes, 10-20  $\mu$ L 25 mM ammonium bicarbonate was added to cover the gel pieces and incubated overnight at 37 °C. The samples were then frozen at -20 °C until analysis by molecular mass sequencing.

LC-MS/MS peptide sequencing and protein identification:

[0314] This was carried out by standard procedures at mass spectrometry sequencing facilities: Mass Consortium, San Diego, CA or Centre Proteomique de l'Est du Québec, Ste-Foy, Quebec, Canada or equivalent facilities. In short, the samples were run on LC-MS/MS ion trap instruments and the parent and fragments are analyzed for mass to charge ratios. From the degradation fragments, a peptide sequence was deduced which is generally within 1 amu of the predicted mass. These sequences were then compared to peptide sequences in the gene sequence or protein sequence databases. Identity of peptide sequence with predicted tryptic fragments from gene sequences indicates the peptide as part of the gene. The size of the peptide matched and/or the number of matched peptides confirm the identity of the protein.

[0315] The following lists the experimentally deduced peptide sequences having the closest fitting calculated molecular weights. An NCBI Blast search (accessible at <http://www.ncbi.nlm.nih.gov/BLAST/>) using these peptides revealed that they are a part of SEQ ID NO: 1 or 4.

<u>Sequence:</u>	<u>aa positions</u>
AVLGTSNFK	amino acids 487-495 of SEQ ID NO.: 1 or 4
GFVEPDHYVVVGAQR	amino acids 395-409 of SEQ ID NO.: 1 or 4
ILNIFGVIK	amino acids 386-394 of SEQ ID NO.: 1 or 4
LAVDEEENADNNTK	amino acids 40-53 of SEQ ID NO.: 1 or 4
LLNENSIVPR	amino acids 146-155 of SEQ ID NO.: 1 or 4
LTTDFGNAEK	amino acids 656-665 of SEQ ID NO.: 1 or 4
LVYLVENPGGYVAYSK	amino acids 209-224 of SEQ ID NO.: 1 or 4
SAFSNLFGGEPLSYTR	amino acids 7-22 of SEQ ID NO.: 1 or 4

SSGLPNIPVQTISR	amino acids 326-339 of SEQ ID NO.: 1 or 4
VSASPLLYTLIEK	amino acids 496-508 of SEQ ID NO.: 1 or 4

### EXAMPLE 35

#### Immunofluorescence, Immunohistochemistry, and Electron Microscopy

- [0316] For detecting internalization of fluorescent transferrin receptor, T47D cells were plated on glass cover slips in a 6-well plate at a density of  $3 \times 10^5$  cells per well on the day before the experiment. Cells were pretreated with 2  $\mu$ M GA for 10 min at 37°C washed with PBS, and then labeled for 30 min with 1  $\mu$ g/ml FITC-labeled mouse anti-human transferrin receptor (RDI, Flanders, NJ) at 37°C. The cells were then fixed with methanol at -20°C for 5 min, washed with PBS and mounted with Vectashield mounting medium (Hard set with DAPI, Vector Laboratories, Inc., Burlingame, CA).
- [0317] FACS Analysis: For cell surface staining of transferrin receptor, cells were washed with PBS + 1% BSA and stained with FITC-conjugated anti-transferrin receptor antibody (RDI, Flanders, NJ) for 30 minutes at 4°C. After washing, cells were analyzed on a FACS Calibur (BD Biosciences, San Jose, CA) using Cellquest software.
- [0318] For the immunohistochemistry of tumor sections, tumors were fixed in 10% formaldehyde before sectioning. The sections were blocked with Dako peroxidase block (Dako, Glostrup, Denmark) for 30 min and incubated overnight at 4°C with a 1:50 dilution of cleaved caspase-3 antibody (Cell Signalling Technologies, Beverly, MA). Then sections reacted for 30 min with EnVision+™-rabbit conjugated with peroxidase (Dako, Glostrup, Denmark). The cleaved caspase-3 immunoreactivity was visualized by developing the sections in 3-3'-diaminobenzidine (DAB). Finally the sections were counterstained with hematoxylin.



**[0319]** For electron microscopy, samples were fixed in Karnovsky's fixative (4% paraformaldehyde, 2.5% glutaraldehyde, 5 mM  $\text{CaCl}_2$  in 0.1 M Na Cacodylate buffer, pH 7.4) overnight at 4° C followed by 1%  $\text{OsO}_4$  in 0.1 M Na Cacodylate buffer, pH 7.4, en bloc staining with 4% uranyl acetate in 50% ethanol, and subsequently dehydrated using a graded series of ethanol solutions followed by propylene oxide and infiltration with epoxy resin (Scipoxy 812, Energy Beam Sciences, Agawam, MA). After polymerization at 65°C overnight, thin sections were cut and stained with uranyl acetate (4% uranyl acetate in 50% ethanol) followed by bismuth subnitrate. Sections were examined at an accelerating voltage of 60kV using a Zeiss EM10C electron microscope.

#### EXAMPLE 36

##### siRNA transfections, cDNA synthesis and Real-time PCR

**[0320]** Human transferrin receptor and caspase 8 siRNA oligos were chemically synthesized by Ambion (Austin, TX). The target sequence for the transferrin receptor siRNA was 5' AAC TTC AAG GTT TCT GCC AGC 3' (nucleotides 1480-1497 of SEQ ID NO.: 27) and for caspase 8 was 5' AAG GAA AGT TGG ACA TCC TGA 3' (SEQ ID NO.: 40). The control siRNA oligos, human cyclophilin and negative control scrambled siRNA were also from Ambion. 293T cells were grown to 50% confluence and allowed to attach overnight. siRNAs were transfected into the cells using Lipofectamine 2000 (Invitrogen, Carlsbad, CA) according to the manufacturer's instructions. Briefly, siRNA (at a final concentration of 50 nM) and lipid were individually diluted in low serum media, Opti-MEM (Invitrogen, Carlsbad, CA) and allowed to incubate for 10-30 min after which they were combined and allowed to form lipid complexes for 20 min. The lipid complexes were added onto the cells and allowed to incubate for 48h. The cells were then harvested for RNA, protein, FACS analysis, or DAPI staining.

**[0321]** For cDNA synthesis and quantitative PCR, total RNA was extracted using the TRIzol reagent (Invitrogen, Carlsbad, CA) according to the manufacturer's instructions. Total RNA was quantitated, denatured, and electrophoresed in an agarose-formaldehyde gel to determine integrity of total RNA. 2 µg of total RNA was then used to make cDNA by reverse transcription using the Retroscript cDNA synthesis kit (Ambion Austin, TX) according to the manufacturer's instructions. Both oligo dT and random primers were used to make the cDNA which was used as a template for PCR analysis. Quantitative PCR was done by Sybrgreen incorporation using the Quantitect kit (Qiagen, Valencia, CA) on the LightCycler (Roche Molecular Biochemicals, Mannheim, Germany) using standard conditions. Data was normalized against the housekeeping gene, cyclophilin. The cells transfected with cyclophilin as a control was normalized against glyceraldehyde phosphate dehydrogenase (GAPD).

### EXAMPLE 37

#### Immunoblotting and Immunoprecipitation

**[0322]** Jurkat cells were cultured at  $5 \times 10^6$ /ml after which DMSO or 2060 (5 µM) was added for the time as indicated. Cells were lysed in RIPA buffer (Upstate Biotechnologies, Lake Placid, NY) and were subject to SDS PAGE then blotted onto PVDF membrane. Membranes were probed with anti-caspase 3 (BD Biosciences, San Jose, CA), Caspase 8 (Biosource, Camarillo, CA), Bid (Upstate Biotechnologies, Lake Placid, NY) or Cytochrome c (BD Biosciences, San Jose, CA) at 1µg/ml. For cells treated with the biotinylated caspase inhibitor, fluoromethyl ketone (FK19) (ICN, Costa Mesa, CA), Jurkat cells were also cultured at  $5 \times 10^6$  /ml, FK19 was added at a final concentration of 10 µM for 30min then cells were treated with DMSO or GA (5 µM) for 1hr. Cells were then lysed cell in RIPA buffer (Upstate Biotechnologies, Lake Placid, NY). Lysates were mixed with 100 µl of

streptavidin-agarose beads (Molecular Probes, Eugene, OR) for 2 hr and were subsequently washed and eluted. Samples were subject to SDS/ PAGE analysis and blotted onto nitrocellulose membrane. Membranes were probed with anti-caspase 3 (BD Biosciences, San Jose, CA), caspase 9 (Upstate Biotechnologies, Lake Placid, NY) or Caspase 8 (Biosource, Camarillo, CA) and detected using ECL (enhanced chemiluminescence) reagent (Amersham Biosciences, Piscataway, NJ).

**[0323]** For anti-FITC GA immunoprecipitation, Jurkat cells were treated with either DMSO or 5 $\mu$ M Fluorescein-GA in RPMI and 0.5% FBS for 30 minutes at 37°. Cells were washed two times with PBS and lysed in RIPA buffer plus a protease inhibitor cocktail. Nuclei were spun out.

**[0324]** For the immunoprecipitation, 1 mg of Jurkat lysate was pre-cleared with 50 $\mu$ l Protein A Sepharose (Zymed Laboratories, San Francisco, CA). Lysates were then incubated with 2.5 $\mu$ g of rabbit anti-FITC antibody (Zymed Laboratories, San Francisco, CA) for 2 h at 4°C. Lysates and antibody were then added to 100 $\mu$ l pre-washed Protein A Sepharose and incubated overnight at 4°C. Sepharose was washed six times with RIPA. 20% of the above immunoprecipitation was subjected to SDS-PAGE and transferred to PVDF. Membranes were blocked in 3% milk, 1% BSA and probed with anti-transferrin receptor antibody (Zymed) as described above.

## EXAMPLE 38

### Binding Assays

**[0325]** Saturable and temperature dependent receptor binding on cells. Jurkat cells were grown to medium to late log phase and incubated with tritium-GA at 1  $\mu$ M in growth medium at 37°C with or without 20  $\mu$ M of unlabeled GA. At indicated time points cells were washed with ice-cold PBS at 4°C and the amount of bound tritium-GA was determined by liquid scintillation counting.

**[0326]** 96-well plates were coated with soluble human transferrin receptor (shTR) (Merck Biosciences, Schwalbach, Germany) at 375 ng/well and

blocked with Bovine Serum Albumin (BSA). Wells were incubated with increasing concentrations of biotin-GA in binding/washing buffer containing 0.5 % BSA, 0.1% Tween-20, 150 mM NaCl and 10 mM Tris-HCl (pH 7.4) for 1 hour at room temperature. Wells were washed 4 times, incubated with Eu-Streptavidin (Perkin-Elmer, Wellesey, MA) and washed again. Amounts of bound Eu-Streptavidin were quantified after incubation with Enhancement Solution (Perkin-Elmer, Wellesey, MA) by measuring time-delayed fluorescence on a Wallac Victor plate reader (Perkin-Elmer, Wellesey, MA) according to manufacturer's protocol. Uncoated wells were used to determine background binding. Biotinylated inactive GA (biotin- $\alpha,\beta$  saturated GA) was used as a control and produced only low background signal in both coated and uncoated wells. In competition experiments biotin-GA at 1  $\mu$ M was pre-mixed with increasing amounts of GA or inactive-GA.  $K_d$  and competition  $EC_{50}$  values were calculated using PRIZM software. ShTR-coated wells were incubated with GA-biotin as described above, washed and incubated with non-tagged analogs or binding/washing buffer as a wash off control. Separate control wells were probed with biotinylated holo-transferrin (bio-Trn) to control for TR retention and possible denaturation over long incubation times.

### EXAMPLE 39

#### Transferrin Receptor Binding Assay Of Small Molecules

[0327] The assay was run similar as described in Example 38. Wells of a 96-well assay plate were coated with 500 ng of HTR in 100  $\mu$ l of PBS per well overnight at 4°C. These were washed twice with 200  $\mu$ l of PBS and incubated with 200  $\mu$ l of 1 % BSA solution in PBS and washed twice with 200  $\mu$ l of PBS. 100  $\mu$ l of 1  $\mu$ M biotin-GA solution in binding buffer (PBS/0.1 % BSA/0.1% Tween-20) was added per well and incubated for 45 minutes at room temperature. For competition of binding assays biotin-GA was pre-mixed with indicated compounds at various concentrations. Final concentration of DMSO in binding mixtures was adjusted to 1% v/v. Wells

were washed 4 times with 200 µl of binding buffer. 100 µl of 100 ng/ml Eu-labeled streptavidin solution in binding buffer were added per well and incubated for 45 minutes at room temperature. Wells were washed twice with 200 µl of binding buffer and twice with 200 µl of PBS. 100 µl of DELFIA Enhancement Solution were added per well and incubated for 10 minutes at room temperature. Plates were read on a Wallac Victor plate reader (Wallac-PerkinElmer Life Sciences) using delayed fluorescence Eu protocol at default manufacturer's settings.

[0328] Coated wells with no competing agent added were used to determine total binding (**T**). Non-coated wells were used to determine background binding (**B**). Background binding was consistently lower than 20 %. Inhibition of binding was calculated as  $I = (T-BC)/(T-B) * 100\%$ , where **BC** was a reading corresponding to a well with a competing compound **C** added.

[0329] Other controls included assays of Biotin-GA binding to the wells coated with 500 µg/well of BSA or mouse Immunoglobulin G, the secondary reagent (Eu-labeled streptavidin) alone binding to the wells coated with 500 µg/well of HTR. Non-specific binding in these assays was not significantly higher than background binding to non-coated wells. The results are summarized in Table I.

**Table I. Binding of Small Molecules to Transferrin Receptors by  
Inhibition of Biotin-GA Binding to Transferrin Receptors**

<b>Example #</b>	<b>% Inhibition</b>
Example 17	52
Example 18	42
Example 19	0
Example 22	51
Example 23	59
Example 27	11

Example 28	8
Example 31	47
Example 32	61

Compounds were tested at 20  $\mu$ M. Concentration of biotin-GA was kept at 1  $\mu$ M.

[0330] Table I showed that several small molecules, including the compounds of Examples 17-18, 22-23 and 31-32, have good binding to Transferrin Receptors by inhibiting efficiently the binding of biotin-GA to Transferrin Receptors. Therefore the binding assay can be used to identify compounds that bind to the Transferrin Receptors.

#### EXAMPLE 40

##### Identification Of Small Molecules As Caspase Cascade Activators And Inducers Of Apoptosis In Solid Tumor Cells

[0331] Human breast cancer cell lines T-47D and DLD-1 were grown according to media component mixtures designated by American Type Culture Collection + 10% FCS (Invitrogen Corporation), in a 5 % CO<sub>2</sub> -95 % humidity incubator at 37 °C. T-47D and DLD-1 cells were maintained at a cell density between 50 and 80 % confluency at a cell density of 0.1 to 0.6 x 10<sup>6</sup> cells/mL. Cells were harvested at 600xg and resuspended at 0.65 x 10<sup>6</sup> cells/mL into appropriate media + 10 % FCS. An aliquot of 22.5  $\mu$ L of cells was added to a well of a 384-well microtiter plate containing 2.5  $\mu$ L of a 10 % DMSO in RPMI-1640 media solution containing 0.16 to 100  $\mu$ M of test compound (0.016 to 10  $\mu$ M final). An aliquot of 22.5  $\mu$ L of cells was added to a well of a 384-well microtiter plate containing 2.5  $\mu$ L of a 10 % DMSO in RPMI-1640 media solution without test compound as the control sample. The samples were mixed by agitation and then incubated at 37 °C for 48 h in a 5 % CO<sub>2</sub>-95 % humidity incubator. After incubation, the samples were removed from the incubator and 25  $\mu$ L of a solution containing 14  $\mu$ M of

*N*-(Ac-DEVD)-*N'*-ethoxycarbonyl-R110 (SEQ ID NO.: 41) fluorogenic substrate (Cytovia, Inc.; WO99/18856), 20 % sucrose (Sigma), 20 mM DTT (Sigma), 200 mM NaCl (Sigma), 40 mM Na PIPES buffer pH 7.2 (Sigma), and 500 µg/mL lysolecithin (Calbiochem) was added. The samples were mixed by agitation and incubated at room temperature. Using a fluorescent plate reader (Model SPECTRAfluor Plus, Tecan), an initial reading ( $T = 0$ ) was made approximately 1-2 min after addition of the substrate solution, employing excitation at 485 nm and emission at 530 nm, to determine the background fluorescence of the control sample. After the 3 h incubation, the samples were read for fluorescence as above ( $T = 3$  h).

**Calculation:**

[0332] The Relative Fluorescence Unit values (RFU) were used to calculate the sample readings as follows:

$$\text{RFU}_{(T=3h)} - \text{Control RFU}_{(T=0)} = \text{Net RFU}_{(T=3h)}$$

[0333] The activity of caspase cascade activation was determined by the ratio of the net RFU value for test compound to that of control samples. The  $\text{EC}_{50}$  (nM) was determined by a sigmoidal dose-response calculation (Prism 3.0, GraphPad Software Inc.).

[0334] The caspase activity (Ratio) and potency ( $\text{EC}_{50}$ ) are summarized in Table II:

Table II. Caspase Activity and Potency of Small Molecules

Example #	T-47D	
	Ratio	$\text{EC}_{50}$ (nM)
Example 17	9.8	8383
Example 18	2.9	6603
Example 19	1.0	Inactive
Example 22	9.9	4017
Example 23	14.1	3735
Example 27	1.5	Inactive

Example 28	1.3	Inactive
Example 31	11.4	3854
Example 32	10.6	3092

[0335] Table II shows that several small molecules, including compounds of Example 17-18, 22-23 and 31-32, activate caspases and induce apoptosis in tumor cells. These compounds also have good binding to Transferrin Receptors as shown in Table I in Example 39. Therefore the binding assay can be used to identify compounds that bind to the Transferrin Receptors and are activators of caspases and inducers of apoptosis.

#### EXAMPLE 41

##### Isolation and Identification of Clathrin Heavy Chain

Isolation of clathrin heavy chain from intact cells using FITC-tagged gambogic acid:

[0336] Jurkat cells were grown in RPMI 1640 media containing 25 mM Hepes and L-glutamine (Gibco) supplemented with 10% FCS and penicillin/streptomycin and harvested by centrifugation (200xg, 10 min) when they reached a concentration of  $1 \times 10^6$  cells/ml.  $1 \times 10^9$  Jurkat cells were resuspended in 100 mL RPMI 1640 media with 0.5% FCS. Cells were then treated with either 1% DMSO or 5  $\mu$ M 5-[(5-gambogylaminopentyl)-thioureidyl]-fluorescein (Example 10) in DMSO for 30 minutes at 37 °C. Cells were washed one time with 40 mls phosphate buffered saline (PBS) and lysed in 8 mls RIPA buffer (10x RIPA supplied by Upstate) and 0.1% Protease Inhibitor Cocktail (Sigma). The lysed cells were spun at 20,000xg for 10 min and the supernatant collected and are referred to as "Jurkat lysate."

[0337] Protein concentration of the lysate was determined by DC Assay (BioRad). 30 mgs of Jurkat lysate was mixed with 100  $\mu$ L Protein A Sepharose beads (Zymed) which had been washed 2 times with 1 ml PBS and



incubated at 4° C for 2 hours. The mix was centrifuged 1 minute at 2,700 x g. The supernatant was removed from the Protein A Sepharose beads and 50 µg of rabbit anti-FITC antibody (Zymed) was added. Lysates and antibody were incubated with gentle rocking at 4°C for 2 hours. 100 µL pre-washed Protein A Sepharose beads were added to the mix and further incubated overnight, with gentle rocking at 4°C. The Sepharose beads were collected by centrifugation (2,700 x g, 1 minute) and washed 6 times with 1 ml of PBS + 0.2% NP-40. 100 µL of 2x SDS sample buffer (Invitrogen Corporation) with 40 mM dithiothreitol (DTT) was added to the beads and the beads were boiled at 100°C for 5 minutes. Samples were spun down at 20,000 x g for 1 min and the supernatant removed and loaded onto 6 mm wide well on a 16 cm x 20 cm x 1 mm 4% SDS polyacrylamide gel in Tris-glycine running buffer (Invitrogen Corporation) and run at 35 mA for 4 hours at room temperature. The gel was removed from the glass plate and stained with 1% coomassie blue in 40% methanol, 7.5% acetic acid overnight at room temperature. The gel was destained in a solution of 40% methanol, 7.5% acetic acid with several changes of solution until protein bands were visible. Stained bands were excised with a clean razor blade and stored in microfuge tubes for tryptic digest.

#### Trypsin digestion:

**[0338]** The gel slice was further destained in 30% MeOH until the background was nearly clear. The gel slice was incubated for at least an hour in 500 µL of 100 mM ammonium bicarbonate. Then 150 µL of 100 mM ammonium bicarbonate and 10 µL of 45mM DTT were added and incubated at 60 °C for 30 minutes. Samples were cooled to room temperature and 10 µL of 100 mM iodoacetamide was added and the sample incubated for 30 min in the dark at room temperature. The solution was removed and discarded and 500 µL of 50% acetonitrile and 50% 100 mM ammonium bicarbonate, pH 8.9, were added and the sample incubated with shaking for 1 hour at room temperature.

The gel was removed, cut into 2-3 pieces and transferred to a 200  $\mu$ L Eppendorf tube. 50 $\mu$ L acetonitrile was added for 10-15 minutes and then removed. The gel slices were dried in a Savant rotatory evaporator. The gel pieces were incubated with 10  $\mu$ L of 25mM ammonium bicarbonate containing Promega modified trypsin (sequencing grade) at a concentration such that a substrate to enzyme ratio of 10:1 was achieved (typically 0.1 $\mu$ g). The protein amounts were estimated from the staining intensity of the gel. After 10-15 minutes 10-20  $\mu$ L 25 mM ammonium bicarbonate was added to cover the gel pieces and incubated overnight at 37 °C. The samples were then frozen at -20 °C until analysis by molecular mass sequencing.

LC-MS/MS peptide sequencing and protein identification:

[0339] This was carried out by standard procedures at mass spectrometry sequencing facilities: Mass Consortium, San Diego, CA or Centre Proteomique de l'Est du Québec, Ste-Foy, Quebec, Canada or equivalent facilities. The samples were run on LC-MS/MS ion trap instruments and the parent and fragments are analyzed for mass to charge ratios. From the degradation fragments, a peptide sequence is deduced which is generally within 1 amu (atomic mass unit) of the predicted mass. These sequences are then compared to peptide sequences in gene sequence or protein sequence databases. Identity of peptide sequence with predicted tryptic fragments from gene sequences indicates the peptide as part of the gene. The size of the peptide matched and/or the number of matched peptides confirm the identity of the protein.

[0340] The following table lists the experimentally determined molecular weights, Mr(expt), of the column fractions, and peptides having the closest fitting calculated molecular weight, Mr(calc). The difference between Mr(expt) and Mr(calc) is indicated as "Delta." An NCBI Blast search (accessible at <http://www.ncbi.nlm.nih.gov/BLAST/>) using these peptides revealed that they are a part of SEQ ID NO: 34. Query refers to the sample

number, Observed is the m/z ratio, Mr(expt) is the experimental mass adjusted for charge, Mr(calc) is the predicted peptide mass, Delta is the difference between the experimental and calculated mass, and Peptide is the amino acid sequence.

Query	Observed	Mr(expt)	Mr(calc)	Delta	Peptide
232	443.20	884.38	884.40	-0.02	AYEFAER (amino acids 1095-1101 of SEQ ID NO. 34)
242	445.28	888.54	889.45	-0.91	LDASESLR (amino acids 1613-1620 of SEQ ID NO. 34)
297	470.70	939.38	939.45	-0.06	VMEYINR + Oxidation (M) (amino acids 1040-1046 of SEQ ID NO. 34)
373	522.14	1042.26	1042.44	-0.17	ENPYYDSR (amino acids 896-903 of SEQ ID NO. 34)
551	652.83	1303.64	1303.65	-0.01	NNLAGAEELFAR (amino acids 355-366 of SEQ ID NO. 34)
563	438.49	1312.45	1312.71	-0.27	LEKHELIEFR (amino acids 1499-1508 of SEQ ID NO. 34)
592	667.86	1333.70	1333.63	0.08	IYIDSNNNPER (amino acids 882-892 of SEQ ID NO. 34)
624	677.15	1352.28	1352.68	-0.39	VVGAMQLYSVDR + Oxidation (M) (amino acids 177-188 of SEQ ID NO. 34)
642	457.00	1367.98	1367.69	0.29	NNRPSEGPLQTR (amino acids 572-583 of SEQ ID NO. 34)
673	702.04	1402.06	1401.67	0.39	CNEPAVWSQLAK (amino acids 1102-1113 of SEQ ID NO. 34)
686	708.14	1414.26	1414.72	-0.46	IVLDNSVFSEHR (amino acids 1011-1022 of SEQ ID NO. 34)
739	489.27	1464.79	1463.73	1.06	ALEHFTDLYDIK (amino acids 626-637 of SEQ ID NO. 34)

837	776.21	1550.40	1550.75	-0.34	GQFSTDELVAEVEK (amino acids 838-851 of SEQ ID NO. 34)
882	525.34	1573.00	1572.79	0.20	RPISADSAIMNPASK + Oxidation (M) (amino acids 64-78 of SEQ ID NO. 34)
925	806.97	1611.92	1611.84	0.08	ESYVETELIFALAK (amino acids 1166-1179 of SEQ ID NO. 34)
1195	981.65	1961.28	1962.00	-0.72	AFMTADLPNELIELL- EK + Oxidation (M) (amino acids 994-1010 of SEQ ID NO. 34)
1250	1020.57	2039.12	2040.08	-0.96	LPVVIGGLLDVDCS- EDVIK(amino acids 812-830 of SEQ ID NO. 34)
1284	707.71	2120.11	2120.03	0.08	DTELAEELLQWFLQ- EEK (amino acids 1546- 1562 of SEQ ID NO. 34)
1409	785.79	2354.35	2354.14	0.21	SVNESLNNLFITEED- YQALR(amino acids 1462-1481of SEQ ID NO. 34)
1570	961.42	2881.24	2880.51	0.73	RPLIDQVVQTALSE- TQDPEEVSVTVK (amino acids 968-993 of SEQ ID NO. 34)

#### EXAMPLE 42

Isolation and Identification of IQ motif containing GTPase Activating Protein

Isolation of IQ motif containing GTPase Activating Protein from intact cells using FITC-tagged gambogic acid:

[0341] Jurkat cells were grown in RPMI 1640 media containing 25 mM Hepes and L-glutamine (Gibco) supplemented with 10% FCS and penicillin/streptomycin and harvested by centrifugation (200xg, 10 min) when they reached a concentration of  $1 \times 10^6$  cells/ml.  $1 \times 10^9$  Jurkat cells were resuspended in 100 mL RPMI 1640 media with 0.5% FCS. Cells were then

treated with either 1% DMSO or 5  $\mu$ M 5-[(5-gambogylaminopentyl)-thioureidyl]-fluorescein (Example 10) in DMSO for 30 minutes at 37 °C. Cells were washed one time with 40 mls phosphate buffered saline (PBS) and lysed in 8 mls RIPA buffer (10x RIPA supplied by Upstate) and 0.1% Protease Inhibitor Cocktail (Sigma). The lysed cells were spun at 20,000xg for 10 min and the supernatant collected and are referred to as "Jurkat lysate."

[0342] Protein concentration of the lysate was determined by DC Assay (BioRad). 30 mgs of Jurkat lysate was mixed with 100  $\mu$ L Protein A Sepharose beads (Zymed) which had been washed 2 times with 1 ml PBS and incubated at 4° C for 2 hours. The mix was centrifuged 1 minute at 2,700 x g. The supernatant was removed from the Protein A Sepharose beads and 50  $\mu$ g of rabbit anti-FITC antibody (Zymed) was added. Lysates and antibody were incubated with gentle rocking at 4°C for 2 hours. 100  $\mu$ L pre-washed Protein A Sepharose beads were added to the mix and further incubated overnight, with gentle rocking at 4°C. The Sepharose beads were collected by centrifugation (2,700 x g, 1 minute) and washed 6 times with 1 ml of PBS + 0.2% NP-40. 100  $\mu$ L of 2x SDS sample buffer (Invitrogen Corporation) with 40 mM dithiothreitol (DTT) was added to the beads and the beads were boiled at 100°C for 5 minutes. Samples were spun down at 20,000 x g for 1 min and the supernatant removed and loaded onto 6 mm wide well on a 16 cm x 20 cm x 1 mm 4% SDS polyacrylamide gel in Tris-glycine running buffer (Invitrogen Corporation) and run at 35 mA for 4 hours at room temperature. The gel was removed from the glass plate and stained with 1% coomassie blue in 40% methanol, 7.5% acetic acid overnight at room temperature. The gel was destained in a solution of 40% methanol, 7.5% acetic acid with several changes of solution until protein bands were visible. Stained bands were excised with a clean razor blade and stored in microfuge tubes for tryptic digest.

Trypsin digestion:

[0343] The gel slice was further destained in 30% MeOH until the background was nearly clear. The gel slice was incubated for at least an hour in 500  $\mu$ L of 100 mM ammonium bicarbonate. Then 150  $\mu$ L of 100 mM ammonium bicarbonate and 10  $\mu$ L of 45mM DTT were added and incubated at 60 °C for 30 minutes. Samples were cooled to room temperature and 10  $\mu$ L of 100 mM iodoacetamide was added and the sample incubated for 30 min in the dark at room temperature. The solution was removed and discarded and 500  $\mu$ L of 50% acetonitrile and 50% 100 mM ammonium bicarbonate, pH 8.9, were added and the sample incubated with shaking for 1 hour at room temperature. The gel was removed, cut into 2-3 pieces and transferred to a 200  $\mu$ L Eppendorf tube. 50 $\mu$ L acetonitrile was added for 10-15 minutes and then removed. The gel slices were dried in a Savant rotatory evaporator. The gel pieces were incubated with 10  $\mu$ L of 25mM ammonium bicarbonate containing Promega modified trypsin (sequencing grade) at a concentration such that a substrate to enzyme ratio of 10:1 was achieved (typically 0.1 $\mu$ g). The protein amounts were estimated from the staining intensity of the gel. After 10-15 minutes 10-20  $\mu$ L 25 mM ammonium bicarbonate was added to cover the gel pieces and incubated overnight at 37 °C. The samples were then frozen at -20 °C until analysis by molecular mass sequencing.

LC-MS/MS peptide sequencing and protein identification:

[0344] This was carried out by standard procedures at mass spectrometry sequencing facilities: Mass Consortium, San Diego, CA or Centre Proteomique de l'Est du Québec, Ste-Foy, Quebec, Canada or equivalent facilities. The samples were run on LC-MS/MS ion trap instruments and the parent and fragments are analyzed for mass to charge ratios. From the degradation fragments, a peptide sequence is deduced which is generally within 1 amu (atomic mass unit) of the predicted mass. These sequences are then compared to peptide sequences in gene sequence or protein sequence

databases. Identity of peptide sequence with predicted tryptic fragments from gene sequences indicates the peptide as part of the gene. The size of the peptide matched and/or the number of matched peptides confirm the identity of the protein.

[0345] The following table lists the experimentally determined molecular weights, Mr(expt), of the column fractions, and peptides having the closest fitting calculated molecular weight, Mr(calc). The difference between Mr(expt) and Mr(calc) is indicated as "Delta." An NCBI Blast search (accessible at <http://www.ncbi.nlm.nih.gov/BLAST/>) using these peptides revealed that they are a part of SEQ ID NO: 36. Query refers to the sample number, Observed is the m/z ratio, Mr(expt) is the experimental mass adjusted for charge, Mr(calc) is the predicted peptide mass, Delta is the difference between the experimental and calculated mass, and Peptide is the amino acid sequence.

Query	Observed	Mr(expt)	Mr(calc)	Delta	Peptide
225	465.51	929.00	930.50	-1.50	TALQEEIK (amino acids 1028-1035 of SEQ ID NO.: 36)
254	508.23	1014.44	1014.49	-0.05	MLQHAASNK+Oxidation (M) (amino acids 1231-1239 of SEQ ID NO.: 36)
287	547.15	1092.28	1092.48	-0.19	LTAEEMDER (amino acids 26-34 of SEQ ID NO.: 36)
312	589.01	1176.00	1175.57	0.44	EDSNLTLQEK (amino acids 1446-1455 of SEQ ID NO.: 36)
331	617.58	1233.14	1232.59	0.55	FPDAGEDELLK (amino acids 1175-1185 of SEQ ID NO.: 36)
502	735.11	1468.20	1467.66	0.55	VDFTEEEINNMK (amino acids 175-186 of SEQ ID NO.: 36)
508	742.83	1483.64	1483.65	-0.01	VDFTEEEINNMK +Oxidation (M) (amino acids 175-186 of SEQ ID NO.: 36)

509	745.88	1489.74	1489.76	-0.02	SVKEDSNLTLQEK (amino acids 1443-1455 of SEQ ID NO.: 36)
535	783.23	1564.44	1564.65	-0.20	FDVPGDENAEMDAR (amino acids 1369-1382 of SEQ ID NO.: 36)
539	791.27	1580.52	1580.64	-0.12	FDVPGDENAEMDAR +Oxidation (M) (amino acids 1369-1382 of SEQ ID NO.: 36)
561	544.15	1629.43	1628.72	0.71	NKEQLSDMMMINK +3 Oxidation (M) (amino acids 941-953 of SEQ ID NO.: 36)

#### EXAMPLE 43

##### Isolation and Identification of Heat Shock Protein

Isolation of heat shock protein from plasma membrane fraction of Jurkat cells by gambogyl affinity chromatography:

[0346] Jurkat cells were grown in RPMI 1640 media containing 25 mM Hepes and L-glutamine (Gibco) supplemented with 10 % FCS and penicillin/streptomycin and harvested by centrifugation (200 x g, 10 minutes) when they reached a concentration of  $1 \times 10^6$  cells/mL.  $5 \times 10^9$  Jurkat cells were resuspended gently in 4 mL of 10 mM Tris, pH 7.5, with 4  $\mu$ L of Protease Inhibitor Cocktail (P3840, Sigma) and incubated on ice for 10 minutes. Cells were homogenized with a Dounce homogenizer and type A pestle for five minutes on ice. Cell lysates were stored in microfuge tubes and frozen.

[0347] For plasma membrane isolation, 2 mL of lysate was placed into an ultracentrifuge tube (Ultraclear, 15 mL tube, for Beckman rotor JS24.15) along with 2 mL of 60 % sucrose, 10 mM Tris, pH 7.5, and mixed. 7 mL of 20 % sucrose, 10 mM Tris, pH 7.5, solution was carefully layered onto the lysate and the meniscus marked. 4 mL of a 10 % sucrose, 10 mM Tris, pH 7.5, solution was carefully layered on. The tubes were spun at 22,000 rpm (93,000



x g) for 2 hours at 4 °C. The membrane fraction which is seen at the 10 % and 20 % sucrose interface (indicated by the meniscus mark) was carefully removed (approximately 3 mL) with a syringe and needle by side puncture of the tube. The membrane fraction was put into a new ultracentrifuge tube, 12 mL of 10 mM Tris, pH 7.5, 140 mM NaCl was added, the solution mixed by inverting the covered tube, and centrifuged at 22,000 rpm for 1 hour at 4 °C. The supernatant liquid was removed down close to the cloudy white pellet and a Pasteur pipette was used to remove the remaining liquid. Tubes were turned upside down on a paper towel to drain. The membrane pellet was resuspended in 50 µL of PBS with 1 % CHAPS, placed in a microfuge tube and frozen. Protein concentration was determined by DC protein assay (BioRad).

**[0348]** 50 µg of membrane protein (approximately 100 µL) was brought up to 500 µL with RIPA buffer (Invitrogen Corporation) and clarified by centrifugation, 60,000 x g, 15 minutes, 4 °C. The supernatant was removed and incubated with gambogyl-R-SS-R'-agarose (Example 13), 60 µL, for 45 minutes at room temperature with gently mixing. (Gambogyl-R-SS-R'-agarose was washed 2 times with 1 mL RIPA buffer prior to use). The beads were collected by centrifugation (2,700 x g, 1 minute). Beads were washed 2 times with RIPA buffer and then 2 times with RIPA buffer adjusted to 350 mM NaCl. Washes were done at room temperature, 5 minutes each, and the beads were collected by centrifugation (2,700xg 1 minute). 20 µL RIPA buffer and 80 µL 2x SDS sample buffer (Invitrogen Corporation) with 40 mM DTT was added to the beads and boiled for 5 min. The beads were spun down by centrifugation and the supernatant was removed and loaded onto 6 mm wide 6 % SDS polyacrylamide gels (16 cm x 20 cm x 1 mm) in Tris-glycine running buffer (Invitrogen Corporation) at 35 mA for 4 hours at room temperature.

**[0349]** Proteins are resolved by electrophoresis on a 6 % polyacrylamide gel. The gel was removed from the glass plate and stained with 1 % coomassie blue in 40 % methanol, 7.5 % acetic acid overnight at room temperature. The gel was destained in a solution of 40 % methanol, 7.5 % acetic acid with

several changes of solution until protein bands are visible. Stained bands were excised with a clean razor blade and stored in a microfuge tube for tryptic digestion.

#### Trypsin digestion:

[0350] The gel slice was further destained in 30 % MeOH until the background was nearly clear. The gel slice was incubated for at least an hour in 500  $\mu$ L of 100 mM ammonium bicarbonate. Then 150  $\mu$ L of 100 mM ammonium bicarbonate and 10  $\mu$ L of 45mM DTT was added and incubated at 60 °C for 30 minutes. Samples were cooled to room temperature and 10  $\mu$ L of 100 mM iodoacetamide was added and the sample incubated for 30 minutes in the dark at room temperature. The solution was removed and discarded and 500  $\mu$ L of 50 % acetonitrile and 50 % 100 mM ammonium bicarbonate, pH 8.9, was added and the sample was incubated with shaking for 1 hour at room temperature. The gel was removed, cut into 2-3 pieces and transferred to a 200  $\mu$ L Eppendorf tube. 50 $\mu$ L acetonitrile was added for 10-15 minutes and then removed. The gel slices were dried in a Savant rotatory evaporator. The gel pieces were incubated with 10  $\mu$ L of 25mM ammonium bicarbonate containing Promega modified trypsin (sequencing grade) at a concentration such that a substrate to enzyme ratio of 10:1 had been achieved (typically 0.1  $\mu$ g). The protein amounts are estimated from the staining intensity of the gel. After 10-15 minutes, 10-20  $\mu$ L 25 mM ammonium bicarbonate was added to cover the gel pieces and incubated overnight at 37 °C. The samples were then frozen at -20 °C until analysis by molecular mass sequencing.

#### LC-MS/MS peptide sequencing and protein identification:

[0351] This was carried out by standard procedures at mass spectrometry sequencing facilities: Mass Consortium, San Diego, CA or Centre Proteomique de l'Est du Québec, Ste-Foy, Quebec, Canada or equivalent facilities. In short, the samples were run on LC-MS/MS ion trap instruments

and the parent and fragments are analyzed for mass to charge ratios. From the degradation fragments, a peptide sequence was deduced which is generally within 1 amu of the predicted mass. These sequences were then compared to peptide sequences in the gene sequence or protein sequence databases. Identity of peptide sequence with predicted tryptic fragments from gene sequences indicates the peptide as part of the gene. The size of the peptide matched and/or the number of matched peptides confirm the identity of the protein.

[0352] The following table lists the experimentally deduced peptide sequences having the closest fitting calculated molecular weights. An NCBI Blast search (accessible at <http://www.ncbi.nlm.nih.gov/BLAST/>) using these peptides revealed that they are a part of SEQ ID NO: 38.

<u>Sequence:</u>	<u>aa positions</u>
ADLINNLGTIAK	amino acids 96-107 of SEQ ID NO.: 38
AKFENLCK	amino acids 558-565 of SEQ ID NO.: 38
ALLFIPR	amino acids 331-337 of SEQ ID NO.: 38
ELISNASDALDK	amino acids 42-53 of SEQ ID NO.: 38
ELISNASDALDKIR	amino acids 42-55 of SEQ ID NO.: 38
ELKIDIIPNPQER	amino acids 70-82 of SEQ ID NO.: 38
EQVANSAFVER	amino acids 492-502 of SEQ ID NO.: 38
FYEAFSK	amino acids 429-435 of SEQ ID NO.: 38
GVVDSIEDLPLNISR	amino acids 379-392 of SEQ ID NO.: 38
HLEINPDHPIVETLR	amino acids 625-639 of SEQ ID NO.: 38
HSQFIGYPITLYLEK	amino acids 205-219 of SEQ ID NO.: 38
HSQFIGYPITLYLEKER	amino acids 205-221 of SEQ ID NO.: 38
KHLEINPDHPIVETLR	amino acids 624-639 of SEQ ID NO.: 38
KHSQFIGYPITLYLEK	amino acids 204-219 of SEQ ID NO.: 38
NPDDITQEEYGEFYK	amino acids 292-306 of SEQ ID NO.: 38
RAPFDLFENK	amino acids 338-347 of SEQ ID NO.: 38
SIYYITGESK	amino acids 482-491 of SEQ ID NO.: 38
SIYYITGESKEQVANSAFVER	amino acids 482-502 of SEQ ID NO.: 38
SLTNDWEDHLAVK	amino acids 307-319 of SEQ ID NO.: 38
SLVSVTK	amino acids 532-538 of SEQ ID NO.: 38
TLTLVDTGIGMTK	amino acids 83-95 of SEQ ID NO.: 38
YESLTDPSKLDGK	amino acids 56-69 of SEQ ID NO.: 38
YIDQEELNK	amino acids 276-284 of SEQ ID NO.: 38

**[0353]** Having now fully described this invention, it will be understood by those of ordinary skill in the art that the same can be performed within a wide and equivalent range of conditions, formulations and other parameters without affecting the scope of the invention or any embodiment thereof. All patents, patent applications and publications cited herein are fully incorporated by reference herein in their entirety.